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An Illustrated Weekly Journal.

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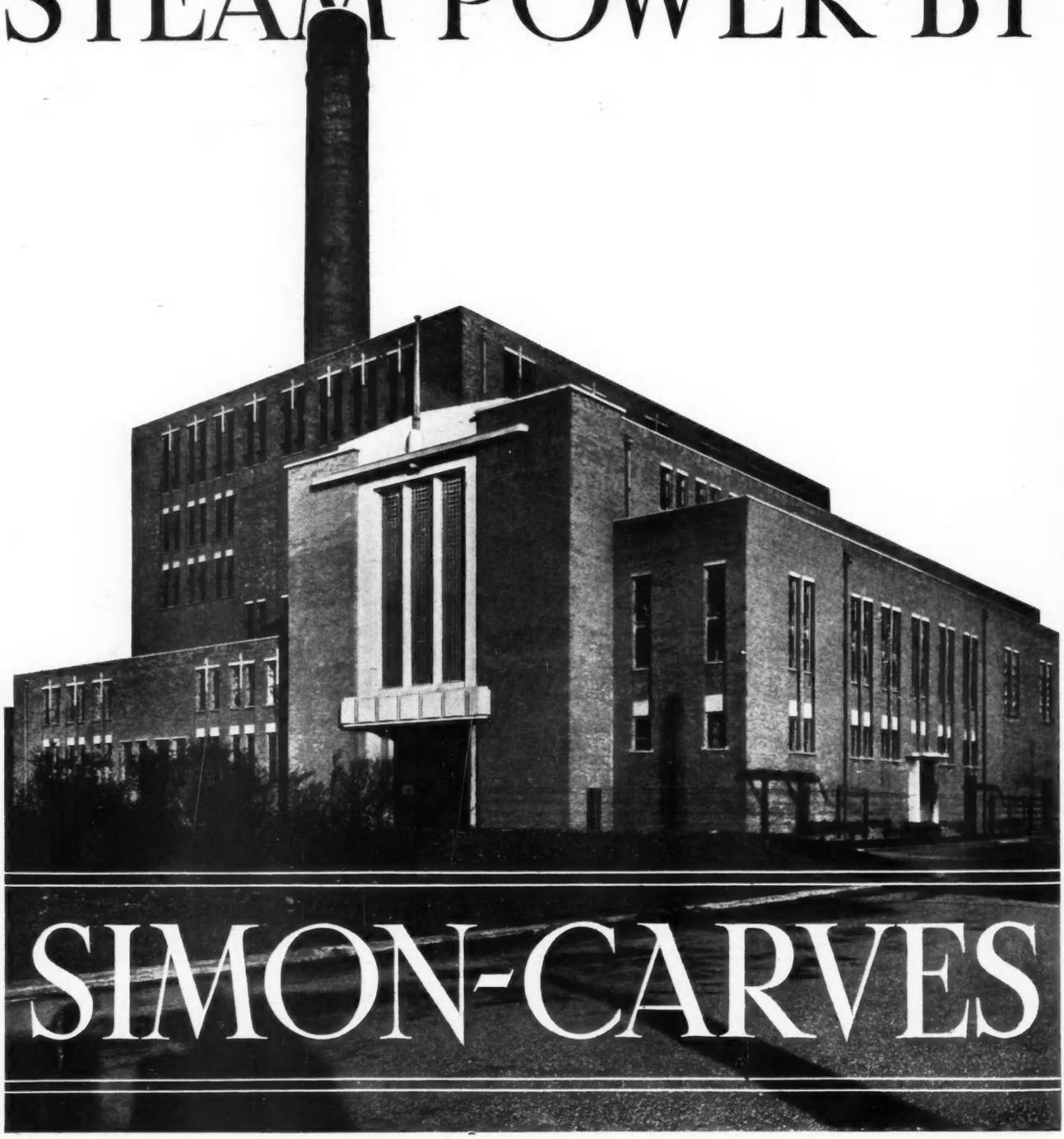

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47.

ENGINEERING AND MARINE EXHIBITION AT OLYMPIA,

INCORPORATING THE FOUNDRY TRADES' AND WELDING EXHIBITIONS.

FEW exhibitors at, or visitors to, the Engineering and Marine Exhibition held at Olympia in the autumn of 1937, could, we imagine, have had any idea that a decade would elapse before its successors would be held. Fourteen of these exhibitions, though the title was not always the same, had taken place between 1906 and 1937, an average of about one every two years, this period covering the war years 1914-1918. The fifteenth exhibition, and Traders, Limited (Marine Section), the British Electrical and Allied Manufacturers' Association (Incorporated), the Foundry Trades' Equipment and Supplies Association, Limited, the Institute of Welding, and the British Acetylene Association. The honorary president of the exhibition is Lieut.-Colonel Lord Dudley Gordon, D.S.O. The organisers are Messrs. F. W. Bridges and Sons, Limited, Grand Buildings, Trafalgar-square, London, W.C.2.

established practice of describing in some detail only those exhibits which are entirely new or which have not been dealt with before in these columns. On the other hand, a fairly considerable number of exhibits have been so described at the time of their introduction to the public, and so, in these cases, the interested reader is referred to the issue in which the account has appeared for the additional information of which he may be in need.

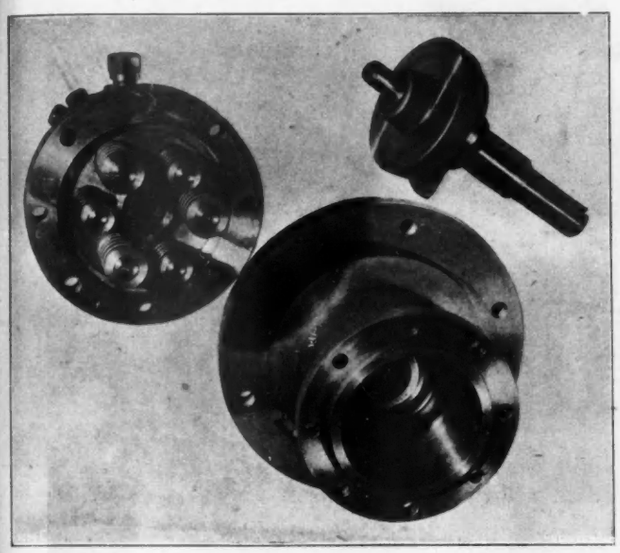


FIG. 1.

FIG. 2.

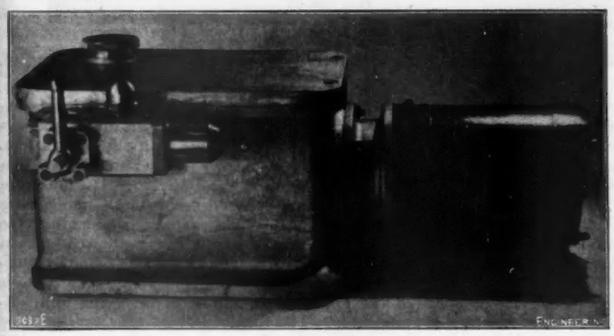
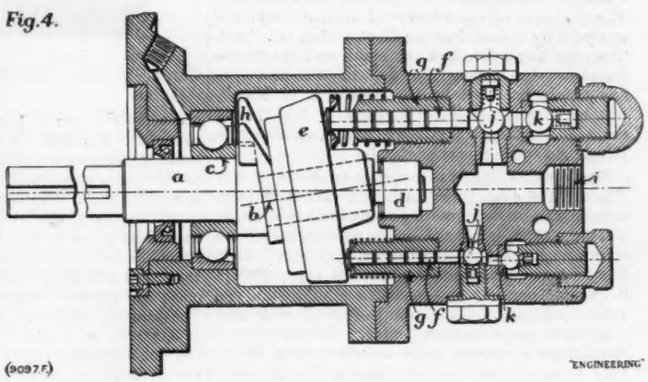


FIG. 3.

Fig.4.



FIGS. 1 TO 4. BEACHAM HIGH-PRESSURE OIL PUMP; MESSRS. OSWALDS AND RIDGWAY, LIMITED.

which was opened in the main hall at Olympia on Thursday, August 28, was to have been held in 1939 and preparations for it were well advanced; but the imminence of war enforced a postponement, as had happened also in 1914. The full title of the exhibition now proceeding is "The Engineering and Marine Exhibition, incorporating the Foundry Trades' Exhibition and the Welding Exhibition." It will remain open daily, between 11 a.m. and 9 p.m., Sundays excepted, until, and including, Saturday, September 13. The title, as given above, naturally postulates support by the technical organisations of the several industries covered. These bodies are the British Engineers' Association (Incorporated), the Society of Motor Manufacturers

It will be obvious that, since a number of different industries are represented on the stands of the exhibition, there being considerably over 400 exhibitors, the display as a whole has what may be termed a miscellaneous character. In presenting our customary account of the exhibits, therefore, no attempt has been made at classification and, in consequence, our review may seem somewhat inconsecutive. The arrangement adopted does not indicate the relative importance of the exhibits by the order in which they are presented—obviously, that must be a matter of the individual opinion of visitors—nor does it follow that the whole of the exhibits on each stand are categorically listed. In this latter respect, we have followed our long-

A high-pressure hydraulic pump suitable for operating presses, machine-tool movements, jacks, and similar machines and apparatus is shown by Messrs. Oswalds and Ridgway, Limited, Sleaford Works, 30, Strutton-ground, London, S.W.1. The pump is shown in several forms and sizes and has been designed by Mr. T. E. Beacham, B.Sc., M.I.C.E. It is of the swashplate type, but the universal joints and connecting rods usually found in swashplate mechanisms have been eliminated, with the result that the Beacham pump is compact and has a minimum of working parts. It has an efficiency exceeding 90 per cent. over a wide range of conditions, so that there is little heating up of the oil handled. The pump body, seen in

the lower part of Fig. 1, page 193, is formed with a flange so that it can be coupled directly to a motor or other prime mover, or a pulley for a belt drive can be fitted. The position of the pump is immaterial, the only restriction being that, wherever possible, it should be submerged in the oil tank or that the tank should be higher than the pump, so that the suction is flooded and consequent inward leakage of air, through possible faulty joints, etc., is prevented. It is seen in a vertical position, with the motor external to the tank, in Fig. 2, and in the horizontal position in Fig. 3, page 193. The combination of pump and oil tank in these two units shows that the set is self-contained. The return flow from the apparatus served passes through a filter inside the tank.

The construction of the pump is best seen in Fig. 4, but it is necessary at this point to state that the particular design shown is of the duplex pump, this pump having two sizes of ram. The single pump, which has only one size of ram, however, is similar in design and in all details except the controls, so that it is unnecessary to illustrate it separately. Referring to Fig. 4, the driving shaft is indicated at *a*. It is formed with an inclined crank *b*, that is, a crank of which the axis describes the envelope of a double cone when the shaft is rotated. The shaft is mounted in ball bearings at both *c* and *d*. The swashplate, *e*, is not integral with the driving shaft, but the crank is free to rotate in it. The net result is that the swashplate, which is in contact with the hemispherical ends of the rams *f*, does not rotate but is given an all-round tilting movement which depresses the rams in succession. The return stroke of the rams is effected by helical springs in compression. The cylinders *g* are screwed into the body of the pump. They have no glands, oil-tightness of the rams being secured by peripheral grooves. The swashplate is kept from rotating on the crank by the friction between its face and the ends of the rams. This has an important effect upon wear, since there is no continuous rubbing contact between the surfaces. At the same time, there is a small rotary oscillation of the rams in their cylinders and a minute constant differential rotary movement. These movements, however, do not result in any notable degree of wear. Exhibited on the stand is an actual swashplate after a running period of 1,000 hours under continuous pressure ranging from 2,000 lb. to 6,000 lb. per square inch.; the original grinding marks are still visible over the entire contact surface. The geometry of the differential movements is well analysed by a clear diagram displayed on the stand. The centrifugal forces of the crank and the inertia forces on the swashplate due to the rams are adequately balanced by the weight *h*, in Fig. 4, which is attached to the driving shaft. The driving shaft, swashplate, and balance weight are shown in the right-hand top part of Fig. 1.

The common inlet to the rams is shown at *i* in Fig. 4. There are three small rams and three large ones in the duplex pump, arranged alternately, as will be clear from Fig. 1. The suction valves are shown at *j* in Fig. 4, and the delivery valves at *k*. They are of the spring-loaded ball type, though in some more recent designs mushroom-type valves are used. Each group of small rams and large rams has a separate outlet. For the sake of simplicity the several ports are not shown, but it may be noted that the two outlets thus provided are fitted with a lever-operated valve external to the pump body. This lever has four operating positions, in the first of which all the rams are by-passed to the tank. In the second position the large rams are by-passed and only the small rams deliver; in the third position the conditions are reversed; and in the fourth position both sets of rams are in action. This arrangement thus provides three different capacities and an "off" position with one pump. If a two-speed motor is used, six capacities are available. The valve is not to be confused with that seen on the side of the tank in Fig. 3, which is for reversing the direction of delivery and is useful, for instance, for a power return stroke.

As regards delivery capacity, the pumps are normally suitable for speeds up to 1,500 r.p.m. and run quietly and without pulsations. Of the 13 sizes of single pump manufactured at present the smallest has a delivery of 0·11 gallon per minute at 1,450 r.p.m. and a pressure of 6,000 lb. per square inch; while the largest will deliver 11 gallons per minute at the same speed and at a pressure of 2,000 lb. per square inch. The capacity of the duplex pumps cannot be so simply stated, but it may be noted that, taking one specific size, the delivery at 1,450 r.p.m. is 5·1 gallons per minute from the larger rams and 2·6 gallons per minute from the smaller ones, the pressure being 3,000 lb. per square inch. The duplex pump is also made for a delivery pressure of 6,000 lb. per square inch, and, as in the case of the single pump, it can be supplied in different types for a range of pressures between 2,000 lb. and 6,000 lb. per square inch. As an example of the varied uses to which the Beacham pump can be put Messrs. Oswalds and Ridgway are showing a pipe-bending machine fitted with the pump; it is illustrated in Fig. 2, page 193. This machine was manufactured by Messrs. Commercial Structures, Limited, Staffa-road, London, E.10. The actual operation shown is the bending, through a right angle and in the cold state, of a steel pipe 4 in. in diameter, a former being used. A larger machine, in which the pump is driven by a petrol engine, is to be used for forming, on the site, expansion bends in oil-pipe lines up to 12 in. in diameter.

The exhibit of Messrs. Butters Brothers and Company, Limited, Trafalgar House, Waterloo-place, London, S.W.1, owing to the nature of the firm's products, is confined to diagrams, photographs and models. Of the latter, a scale model of the shipyard Monotower crane, recently introduced, is of considerable interest. We reproduce in Fig. 5, above, a photograph of a 15-ton crane with a jib 127 ft. 6 in. long, though this shows the crane alongside a graving dock and not in a shipyard. The difference in use, however, does not necessitate any difference in construction. When used in shipbuilding, the crane generally runs on rail tracks situated between the slipways, the gauge of the track being approximately 25 ft. As shown, the Monotower crane is of the portal type, full-circle revolving and self-propelling. The full load of 15 tons can be lifted at a radius of 90 ft. or a load of 6 tons at a radius of 126 ft. The 15-ton load can be handled at a hoisting speed of 30 ft. per minute, a luffing speed of 40 ft. per minute, and a slewing-speed, at 90 ft. radius, of 300 ft. per minute. A 6-ton load at 126 ft. radius can be hoisted at 100 ft. per minute. The crane is also fitted with a fast auxiliary lift of 1½ tons capacity, with which hoisting can be done at speeds of from 100 ft. to 150 ft. per minute.

As regards general dimensions, the distance between the centres of the travelling bogies, measured parallel to the rails, is 25 ft. The lattice-type tower is 16 ft. square in plan, and its height is 76 ft. 6 in. from rail level; the bottom of the cabin is about 2 ft. 3 in. higher. Since the cabin does not project much beyond the base, this height and outreach are not so important as the corresponding dimensions of the balance weight. The height from rail level to the underside of the balance weight is 99 ft. 6 in., and the maximum radius is 29 ft. 6 in.

THE ENGINEERING AND MARINE EXHIBITION.

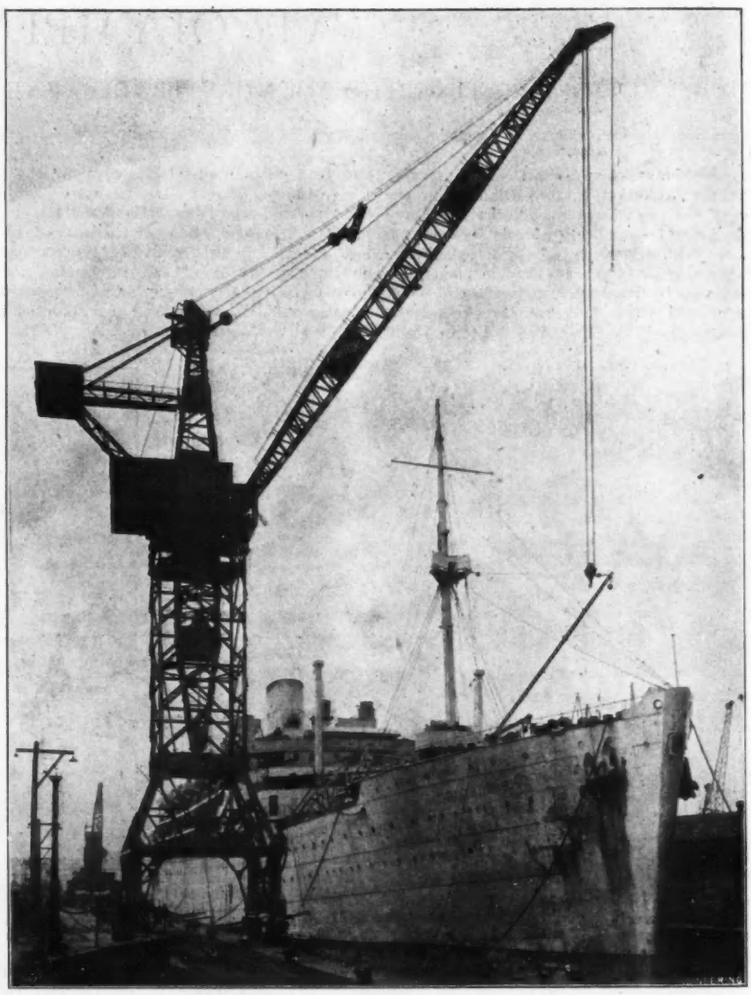


Fig. 5. 15-Ton "Monotower" Shipyard Crane; Messrs. Butters Brothers and Company, Limited.

EXHIBITS AT THE ENGINEERING AND MARINE EXHIBITION.

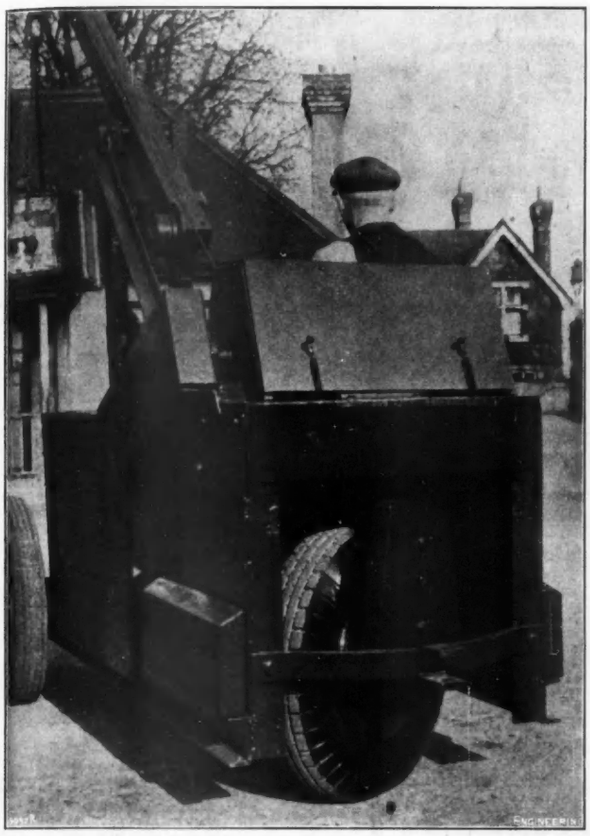
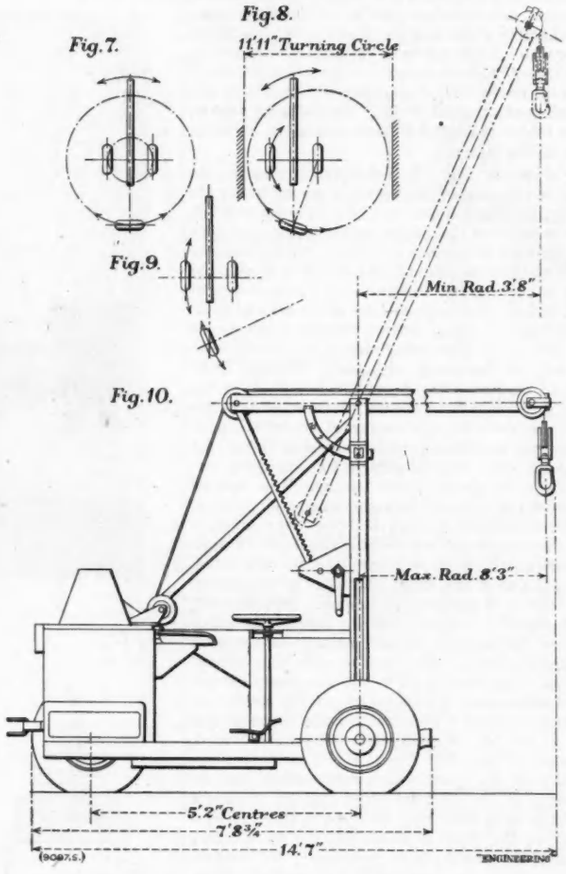


FIG. 6.



FIGS. 6 TO 10. 10-CWT. THREE-WHEEL TRAVELLING CRANE; MESSRS. R. H. NEAL AND COMPANY, LIMITED.

The clearance, when the jib is slewed through 180 deg. for, say, picking up, is thus generally ample for either a ship under construction in a shipyard or lying in a fitting-out basin or dry dock. The Monotower crane is operated by five electric motors. It can be supplied as a stationary crane on a permanent foundation, when the travelling motor, of course, is not required. The normal travelling speed is 75 ft. per minute when a 15-ton load is being carried at 90 ft. radius. The load can be increased to 20 tons with a shorter radius. The 15-ton and 20-ton capacity is about the maximum required for the class of work for which the Monotower crane is designed. The crane can be manufactured for other capacities, and with different lengths of jib. Messrs. Butters' stand also includes scale models of other types of crane made by them.

Messrs. R. H. Neal and Company, Limited, Plant House, Longfield-avenue, Ealing, London, W.5, are showing the new three-wheel mobile crane illustrated in Figs. 6 to 10, on this page. The crane, known as the Neal Type "T-10" Run-about crane, is made in two models, namely, a standard model for working in narrow gangways and a lorry-loading model for yard work and stacking; the latter model is illustrated above. The maximum load is 10 cwt. in both machines and the travelling speed 2¼ m.p.h.; the maximum gradient possible, 1 in 5, and the hoisting speed of 40 ft. per minute, with two-part lift, are also the same. The differences lie in the size of the chassis, the radius of the jib and the height of lift, as well as in the diameter of the turning circle. The small space in which the crane can be turned is due to the mounting of the single rear wheel, which, as will be evident from Fig. 6, is of the castor type; this wheel serves for both driving and steering. For straight-line running in either direction, of course, all three wheels are parallel; when the crane is rotating round the centre of the front axle, to give a slewing movement to the jib, the rear wheel is turned so that its axle is at right angles to the front axle, as shown in Fig. 7. When it is desired to turn about one of the front wheels, the axle setting is as shown in Fig. 8, the turning circle between kerbs being 11 ft. 11 in. For a normal turn at any radius, the axle disposition is as shown in Fig. 9. The diameter of the turning circle for the standard model is 11 ft.

The wheelbase, in both models, is 5 ft. 2 in., and both have heavy-duty 25 in. by 6 in. pneumatic tyres. The distance between central planes of the front wheels is 3 ft. 11 in. for the standard model and 4 ft. 8 in. for the lorry-loading model. Power for travelling and hoisting is provided by an air-cooled industrial petrol engine developing between 5 h.p. and 6 h.p.; the fuel consumption on average duty is about ¼ gallon per hour. Transmission is by bush roller chains and through cone clutches, and a reversing bevel-gear unit. The drive to the rear wheel is through the centre of the castor pivot and thence by bevel and spur gears. Forward and reverse travelling motions are actuated by a single pedal with a neutral position. The lowering and hoisting motions each have a separate lever. Steering is by an ordinary handwheel and there is a foot-operated road brake with locking device. The hoisting unit can be removed and replaced in one piece; it has a brake which enables the load to be raised while it is "on," the brake having to be deliberately released for lowering, thus preventing accidental dropping of the load. The derricking movement of the jib is effected by a rack and pinion device actuated by a crank handle having a locking pin. With the jib in its top position, at 75 deg. to the horizontal, the outreach radius is 3 ft. 8 in. and the maximum load 10 cwt., and with the jib horizontal, the radius is 8 ft. 3 in. and the maximum load 4 cwt. The maximum heights of lift are 13 ft. and 5 ft. 8 in., respectively. These figures apply to the lorry-loading crane. The coupling seen at the rear of the chassis in both Fig. 6 and Fig. 10 is to enable the crane to be employed as a factory tractor for trolley loads up to two tons, when required.

The exhibit of Messrs. Gresham and Craven, Limited, Ordsall-lane, Salford 5, Manchester, of course, includes examples of the firm's well-known injectors and other standard products, but the new Ejectopump shown in operation, and illustrated in Figs. 11 to 14, on page 196, may be described in detail. The Ejectopump is operated by compressed air, at a pressure of from 20 lb. to 60 lb. per square inch, according to requirements, and is designed to handle liquids of any viscosity without agitating them. The suction head is normally 10 ft., but the apparatus can be specially arranged to lift from 20 ft. if required. The maximum discharge head is 50 ft. The pump is made in several types, two of which are seen side by side in Fig. 11. Since this illustration shows only the external appearance, to follow the construction and operation, reference should be made to Figs. 12 to 14, which show the type B Ejectopump, with suction and delivery pipes of 2 in. bore. Since the pump is operated by a constant pressure of air, the valves controlling the suction and delivery strokes are float-actuated. This float is indicated at *a*, in Fig. 12, and slides freely on the tube *b*. This tube is attached to a collar *c* which, in turn, is connected to the spindle of the double-faced operating valve *d*. The valve has a vertical travel of about $\frac{1}{16}$ in. in the chamber *e*, to which the pressure air supply is admitted through the pipe *f*. With the float in its lowest position, as shown in Fig. 12, it will be observed that the pressure air is also admitted, by way of chamber *e'*, to the underside of the flexible

diaphragm *g*, the upper face of which is in contact with the spring-loaded isolating valve *h*. The underside of the isolating valve is in communication with a chamber *i*, as is also the upper face of the diaphragm. The chamber *i* contains an ejector *j*, the operating air for which is derived from chamber *e'*, as shown in Figs. 13 and 14, flowing past the upper face of valve *d* when the float is in its lowest position, that is, at the beginning of a suction stroke. The isolating valve *h* opens into a passage *k* in communication with the body of the pump.

As shown in Fig. 12, the suction stroke is just about to commence. Air pressure on the underside of the diaphragm holds open the isolating valve *h*, and the action of the ejector *j* exhausts the chamber *i* and, through the passage *k*, creates a partial vacuum in the body of the pump. The liquid to be pumped flows in through the flap valve on the suction passage, and the float begins to rise and continues to do so until its top makes contact with the collar *c*. At this point, the float being almost completely submerged, its buoyancy ultimately becomes sufficient to overcome the downward resistance of the valve *d*, derived from the air pressure, so that the valve rises on to its upper seat and cuts off the pressure supply underneath the diaphragm as well as that to the ejector *j*. The diaphragm falls and the isolating valve is closed by its spring. The upward movement of valve *d* opens communication between the pressure chamber *e* and the body of the pump, so that the compressed air reaching the liquid through the port *m*, which can be adjusted by a needle valve, drives it out of the pump through the non-return flap valve *n* of the delivery branch. Displacement of the liquid continues until the float sinks and is arrested by its lower surface making contact with the lower collar *o*. The suction cycle then recommences. Any surplus air left in the pump escapes to the atmosphere through valve *p*. The connection between chamber *e'* and chamber *i* is shown at *q* in Figs. 13 and 14. A small safety valve *r* is provided, as shown in Fig. 12.

Many of the parts enumerated above can be identified in the external view, Fig. 11, though it should be mentioned that the type B 1½-in. Ejectopump, on the right, is shown fitted with windows on the sides for exhibition purposes; the windows are, of course, not provided in the normal pumps. The Ejectopump on the left of Fig. 11 owes its somewhat clumsy appearance to the fact that it is of the chemical type, the body and some other parts being made of glazed stoneware to resist liquids which attack metals. The standard type B has the body made of steel, electrically welded and generally galvanised on both surfaces. The float and float rod are of brass, working in gunmetal guides. All the valves have renewable faces of synthetic rubber. Type A is a simpler form of type B, without supporting legs. Type C has a cast-iron body and is jacketed with steam or with hot or cold water, for use in applications where the liquid is required to be kept at a specified temperature. The output of the pump depends on a variety of factors such as viscosity, air-pressure, etc., but, when pumping water, the output ranges from 400 gallons to 2,000 gallons an hour, over the three sizes, namley, 1½ in., 2 in., and 3 in., in which the pump is made. The range for the corresponding air consumption is from 4 cub. ft. to 15 cub. ft. of free air per minute. The pump is readily kept clean, since the cover on which the mechanism is mounted can be removed for examination of the interior of the body without breaking the joints of the suction and delivery pipes. The only valves in contact with the liquid pumped are the non-return valves in these pipes. No lubrication is necessary for any part. The Ejectopump, we understand, is in use for handling many difficult liquids, such as those containing abrasives, hot bitumen, thick china clay, heavy paints, hot chocolate, glucose, etc.; and even hot and cold jams, and pulps containing fruit stones.

The display of Messrs. W. H. Dorman and Company, Limited, Tixall-road Works, Stafford, comprises a range of four industrial types of compression-ignition engines and five types for marine purposes, together with several examples of reduction gears. We select for description a Dorman-Ricardo V-type Diesel engine, known as type

THE ENGINEERING AND MARINE EXHIBITION.

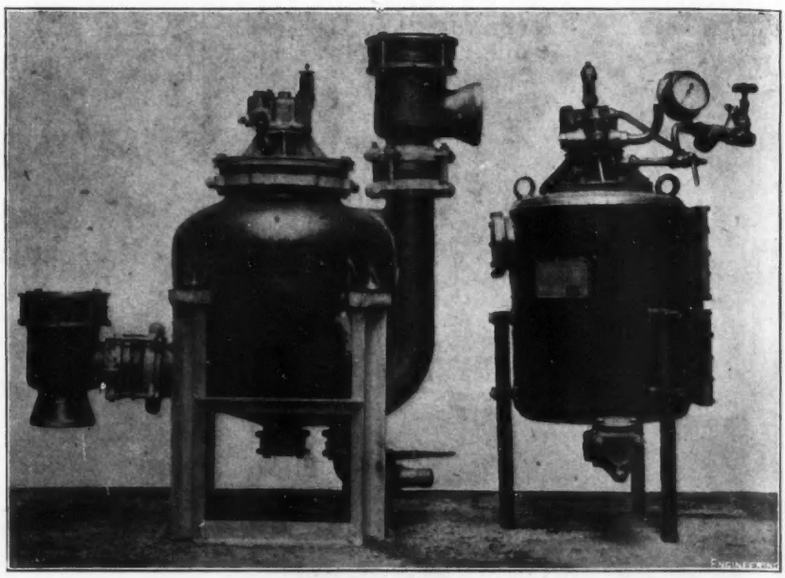


FIG. 11.

Fig. 12

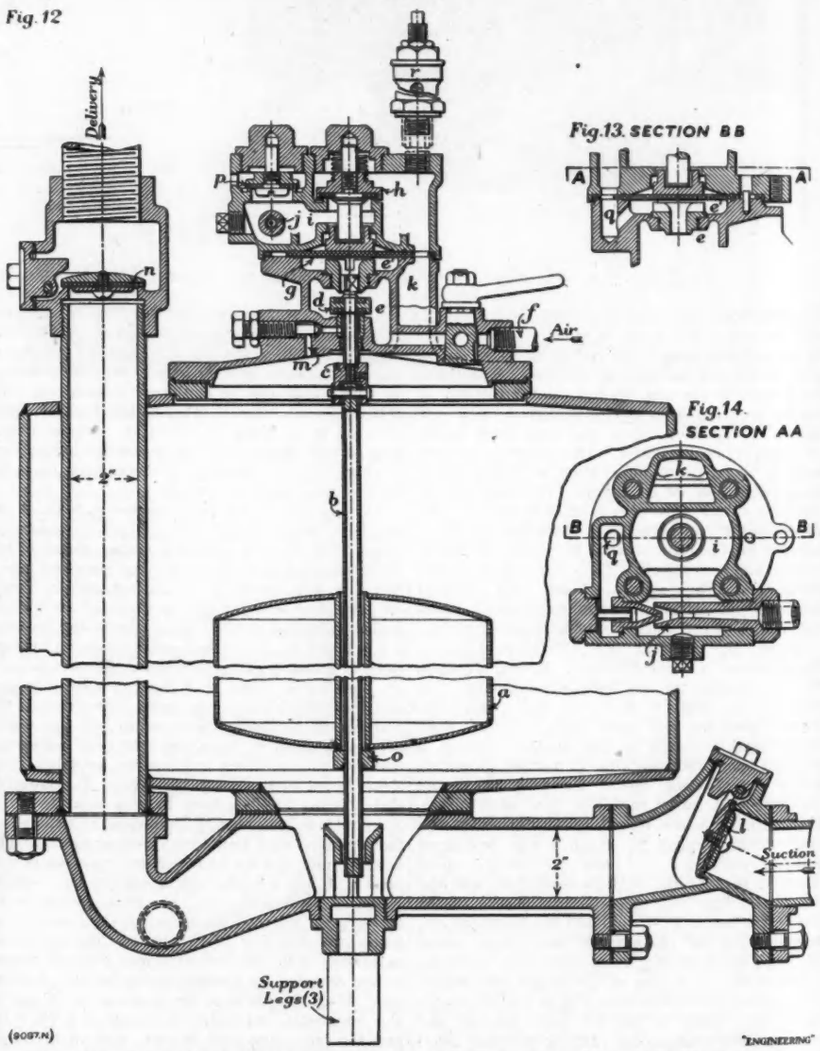


Fig. 13. SECTION BB

Fig. 14. SECTION AA

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FIGS. 11 TO 14. AIR-OPERATED "EJECTOPUMP"; MESSRS. GRESHAM AND CRAVEN, LIMITED.

EXHIBITS AT THE ENGINEERING AND MARINE EXHIBITION.

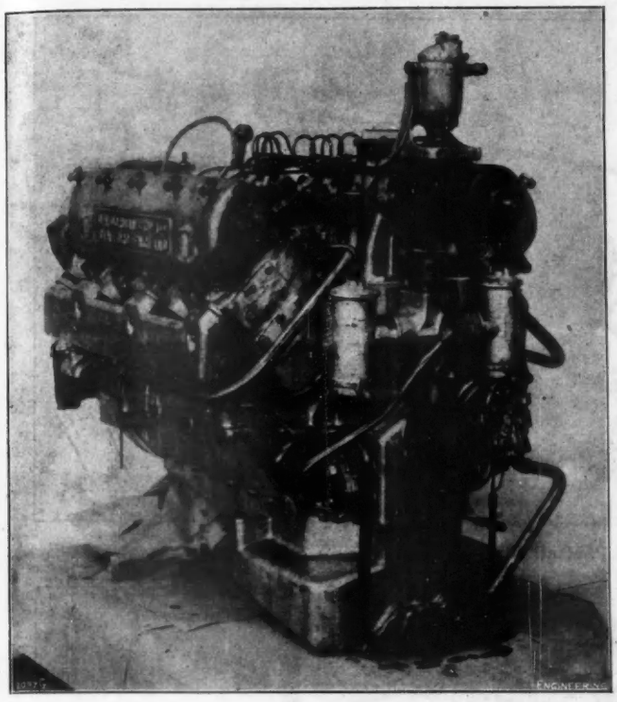


FIG. 15.

Fig. 16.

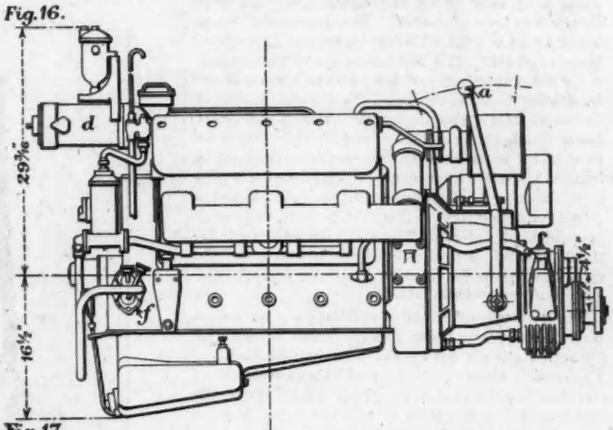
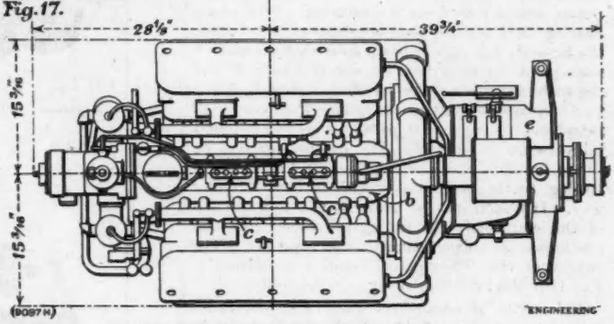


Fig. 17.



FIGS. 15 TO 17. EIGHT-CYLINDER V-TYPE DIESEL ENGINE; MESSRS. W. H. DORMAN AND COMPANY, LIMITED.

8.V.R.M., Mark II.R, and having eight cylinders. The cylinders are of 4¼ in. bore by 4½ in. stroke, and the engine develops from 41 brake horse-power at 1,000 r.p.m. to 100 brake horse-power at 2,200 r.p.m. This power output is the maximum for a four-hour rating at sea level with an ambient temperature of 85 deg. F. The engine is illustrated in Figs. 15 to 17 above, the external view, Fig. 15, being taken from the forward end. It will be evident from Fig. 16 that it is provided with reduction gear since the centre line of the flanged output shaft is 4½ in. below that of the crankshaft. The engine is set on its bearers in the craft concerned at crankshaft level, the depth below the top of the bearers being 16½ in. to the bottom of the T-shaped sump. Since it is designed for marine use, it is reversible, the reversing gear, of which the operating lever is indicated at *a* in Fig. 16, consisting of two multi-plate clutches with alternate bronze and steel plates. One clutch is attached to the crankcase and the other is carried in the flywheel, the reverse being obtained through epicyclic gear. The 2 : 1 reducing gear is fitted directly to the reversing-gear housing and is driven from the output shaft of that gear; the rotation of the propeller shaft, when looking aft, as in Fig. 15, is counter-clockwise. The reversing gear is totally enclosed and runs in oil under pressure. A locking device is incorporated to prevent propeller creep when the engine is idling.

The cylinders are cast in two blocks of four each. They are of a special cast iron with chrome-hardened bores. Efficient water-jacketing, including the exhaust outlet and cylinder heads, is provided. The heads have Ricardo patent combustion chambers and house the overhead valves and rockers. The camshaft and rocker levers are housed in a totally-enclosed casing situated between the cylinders and indicated at *b* in Fig. 17. The camshaft is driven by helical gears from the forward end of the crankshaft, and the five bearings in which it is carried are all pressure-lubricated. As regards the running gear, the crankshaft has four cranks, the pin of each of which takes two connecting rods with a common big-end bearing of steel with centrifugally-cast white-metal liners both internally and externally. Both connecting rods are of I-section, of nickel-chrome steel. One of the rods has a plain end, while the other has a forked end on the common crankpin; the small end of the plain rod has a bronze bush on the gudgeon pin and that of the forked rod is fitted with a bush of Duralumin; all the gudgeon pins are of the fully-floating type and are of case-hardened steel. The pistons are of aluminium alloy, with three pressure rings and one scraper ring above the gudgeon pin and one scraper ring on the skirt. The crankshaft is mounted in five main bearings, 3½ in. in diameter, these have steel shells with copper-lead liners. The bearing caps are on the underside of the crankcase, which extends 6½ in. below the shaft centre line. Attached to the bottom of the crankcase is a sump holding 5½ gallons of lubricating oil, the sump being designed so that the engine may be installed at any desired inclination up to 9½ deg. to the horizontal.

The fuel pump, fuel-lift pump and fuel injectors are standard C.A.V. equipment. The fuel pumps are situated above the camshaft casing and are indicated at *c* in Fig. 17. The governor is of the pneumatic type and controls the engine at idling and maximum speeds. The electrical equipment on the engine consists of a dynamo for lighting and battery-charging, and a starting motor. The dynamo is a C.A.V. 24-volt compensated voltage-controlled machine, gear-driven from the fuel pump drive, which, in turn, is gear-driven from the camshaft. The dynamo is indicated at *d* and is prominent at the top of the engine in Fig. 15. It provides for automatic adjustment of the current for the starting battery, which should have a capacity of approximately 120 ampere-hours. The starting motor is of the C.A.V. "axial" type for 24-volt current, the term "axial" referring to the axial traverse of the driving shaft so that its pinion engages with a toothed ring on the flywheel when the engine is to be started, and is disengaged, when not required, by spring action. The motor is indicated at *e* in Fig. 17. Starting is facilitated by two-volt double-pole heater plugs in the cylinder heads, actuated by a push-type switch. Crank-handle starting is fitted for emergency use. Pressure lubrication is provided by a gear-type pump driven by worm gearing from the crankshaft and shown at *f* in Fig. 16. There is a large gauze filter in the sump on the pump suction, and an Auto-Klean self-cleaning filter on the pump delivery. This filter, with its piping, can be seen on the forward end of the engine in Fig. 15. The circulating water to the cylinder and head jackets is supplied by a gear-type pump driven by the same gear as the oil pump, the water first passing through twin lubricating-oil coolers. The outlet from the heads is provided with a flange, so that the water can be passed finally to the jacket of the exhaust pipe if this is so fitted. The fuel consumption of the Type 8.V.R.M. engine, on an average grade of fuel oil, is 0·45 lb. per brake horse-power hour at 2,000 r.p.m. The net weight of the engine in the form described is 1,880 lb., but a lighter form, Mark I.R, which has some of its parts in aluminium, can be supplied, this engine having a net weight of 1,600 lb. The main object of the design is to provide a Diesel engine suitable for fast motor launches incorporating the advantages of the compression-ignition engine with the low power-weight ratio of the petrol engine.

Two of the five marine engines, running on paraffin, shown by Messrs. Morris Motors, Limited, Engines Branch, Courthouse Green, Coventry, are illustrated in Figs. 18 and 19, page 198. The engine shown in Fig. 18 is the firm's "Navigator" model, having four cylinders, 2·95 in. (75 mm.) bore by 4 in. (102 mm.) stroke, operating on the four-stroke cycle, and develops 11 brake horse-power at 1,000 r.p.m. and 18 brake horse-power at 2,000 r.p.m. It is exhibited with reverse gear and electrical equipment as illustrated, but another example on the stand has reducing gear and no electrical equipment. The body consists of a monobloc casting of hard close-grained grey iron comprising the water-jacketed cylinders and the top part of the crankcase. The bottom part of the crankcase is of a die-cast aluminium alloy capable of resisting sea-water and treated to prevent corrosion. The engine is supported on its bearers by projecting brackets. At the after end of the body is a casing containing the starting gears, and still farther aft are casings housing the reverse gear and the ball-bearing thrust block. The cylin-

drical object on the face of the starting-gear casing is a dynamotor, which provides starting torque when used as a motor and lighting current when functioning as a dynamo. The dynamotor works in conjunction with a 12-volt battery of 63 ampere-hours capacity. The shaft seen above the dynamo is for hand starting, and has provision at each end for taking a crank handle. The reverse gear is of the single-lever planetary type; the ahead clutch has alternate steel and bronze plates, while the astern movement is transmitted through a contracting band. The unit runs in an oil bath, and the gear is self-locking, both ahead and astern. When a 2 to 1 reduction gear is fitted, it permits the use of propellers of different "hands" on twin installations. Double-helical gears are employed to give right-hand propeller rotation and chain and sprocket gear to give left-hand rotation.

The exhaust manifold is external and is water-cooled, the gases being finally cooled before exit by actual contact with water in a mixing chamber. The cooling water, for the cylinders and manifold, is circulated by a gear-type pump driven from the crankshaft. Lubrication is effected by a plunger pump, also driven from the camshaft. The crank bearings and reverse gear are pressure lubricated, the big-ends and pistons being splash-lubricated. A waterproof marine-type magneto is provided, and the carburettor is a single-jet 30-mm. fitting, with a two-way tap for starting the engine from cold with petrol and turning over to paraffin when the required temperature is reached. The carburettor can be set to function with the engine at any angle up to 10 deg. to the horizontal when the boat is under way. Provision can be made at the forward end of the crankshaft for taking off power for such auxiliaries as bilge pumps and capstans. The weight of the "Navigator" engine as shown in Fig. 18 is 595 lb.; the battery weighs 75 lb.

The engine illustrated in Fig. 19 is the firm's "Vedette" marine engine, Mark II. It has four cylinders, 2·444 in. (57 mm.) bore by 3·54 in. (90 mm.) stroke, operating on the four-stroke cycle, and developing 6 brake horse-power at 1,000 r.p.m. and 10 brake horse-power at 2,000 r.p.m. As shown on the stand, and as illustrated, the engine has reverse gear and electrical equipment, but a 2 to 1 reducing gear, of the same general type as on the larger engine described above, can be fitted. An engine fitted with reducing gear, but without electrical gear, is also shown on the stand. While the details are generally of the same type as those of the "Navigator" engine, there are some marked differences in layout. The starter, for example, is on the side of the engine body and its pinion engages with teeth on the flywheel rim; the hand-starter has a chain drive. The sump is a single piece of cast iron, bedding, by flanges, on the engine seating for its whole length. There is provision for auxiliary drives at the forward end of the engine. The standard engine with reverse gear weighs 356 lb.; the reducing gear weighs 25 lb. and the battery 75 lb. The remaining paraffin engine on the stand is a six-cylinder "Commodore" Mark II marine engine, complete with reverse gear and electrical equipment. The cylinders are of 2·953 in. (75 mm.) bore by 4·33 in. (110 mm.) stroke, and the engine develops from 18 to 32 brake horse-power at 900 r.p.m. and 1,900 r.p.m., respectively.

A machine designed for the utilisation of what has been regarded as a waste by-product is shown by Messrs. Product Recoveries, Limited, Fairfield-road, Kingston-upon-Thames. It is known as the Windrum fibre-making machine and appears to possess notable potentialities. It is stated that, after harvesting the linseed crop in Argentina, some 8,000,000 to 10,000,000 tons of straw waste are normally burned annually. It will be understood that, in Great Britain and elsewhere, the straw is retted for the manufacture of flax fibre, the linseed being a by-product. In Argentina, when the plant is grown for the seed, the straw is a by-product and is disposed of as waste, as stated above. After treatment in the Windrum machine, it is held that the unretted crude fibre has a wide prospective market with carpet manufacturers, jute-spinners and the like, since it can be spun usefully with existing machines. The Windrum machine is simple in construction and easy to operate by unskilled labour. It consists

THE ENGINEERING AND MARINE EXHIBITION.

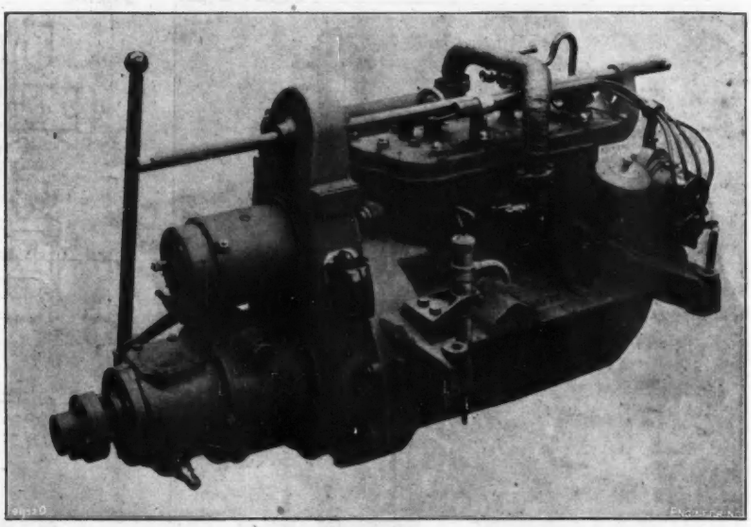


FIG. 18. 11/18-H.P. MARINE PARAFFIN ENGINE; MESSRS. MORRIS MOTORS, LIMITED.

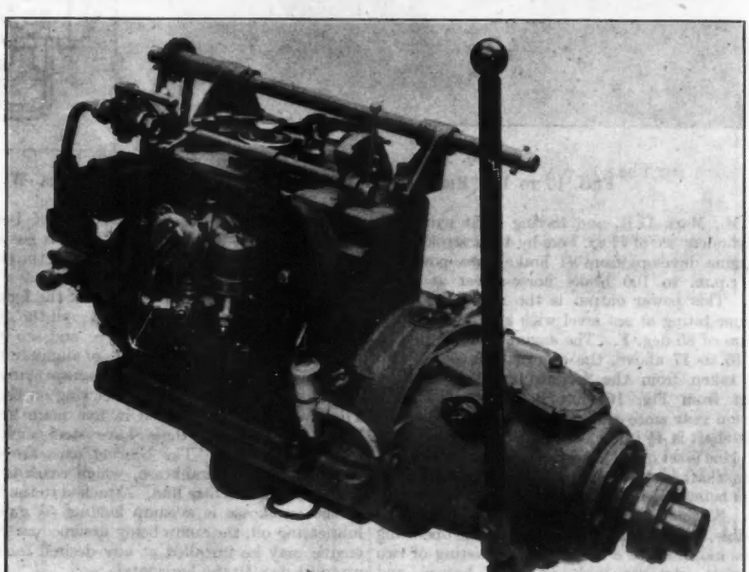


FIG. 19. 6/10-H.P. MARINE PARAFFIN ENGINE; MESSRS. MORRIS MOTORS, LIMITED.

essentially of a wooden feeding platform in front of five pairs of horizontal rotating rollers arranged in series. The straw is first unravelled and then fed, in a thin layer, into the first pair of rolls, suitable guards being provided. These rollers have straight longitudinal flutes, as also have the second pair into which the straw next passes. The fluted rollers crush the straw but do not separate the fibres, which operation is done by the next two pairs of rollers. These have helical grooves, of opposite hands and of wide pitch, and the grooves have the effect of spreading out the fibres in the lateral direction. The final pair of rollers are plain cylinders and are of wood; their function is to deliver what has become, in effect, flax yarn. For some purposes this yarn can be used without further treatment but, usually, it is de-gummed, a process which whitens it, and then it can be spun directly on ring frames or mule frames and mixed, for example, with cotton. The machine is driven by belt from any convenient power source, such as an electric motor, a tractor take-off, or a portable internal-combustion engine. The roller drive from the pulley shaft is through geared idlers to ensure the same direction of rotation in all of them. The delivery rollers are driven by a belt from the last helical-roller shaft, the pulleys being proportioned to give a higher rotational speed to the delivery rollers which results in a pull on the fibres. The roller shafts are carried in phosphor-bronze bearings, and the top rollers are fitted with adjustable spring compressors. It is stated that 600 lb. of fibre can be produced per hour when the designed roller speed of 250 r.p.m. is employed. Applying this figure to factory conditions, a group of 20 machines should produce 15 tons to 20 tons of fibre each working day.

The display of the Hymatic Engineering Company, Limited, Grover-street, Redditch, consists of examples of relatively small air compressors, including the portable and compact petrol-driven unit fully described and illustrated in ENGINEERING, vol. 162, page 309 (1946). This unit, weighing approximately 50 lb., has a piston displacement of 10 cub. ft. per minute at a pressure of 80 lb. per square inch, and is recommended as being suitable for supplying air for pneumatic tools and for spray-

gun equipment on building sites, as well as for insecticide and fruit-tree spraying and dusting, tyre inflation, etc., its self-contained layout being useful in places where no other source of power is available. Some stationary sets from a range of units with capacities up to 40 cub. ft. per minute at a pressure of 175 lb. per square inch are also shown; these machines, which are single-stage, are cooled by high-efficiency fans.

Messrs. W. and T. Avery, Limited, Soho Foundry, Birmingham, 40, are showing, among a variety of other products, the modern 50-ton self-indicating universal testing machine with hydraulic straining gear, which was illustrated and described in the account of the recent British Industries Fair, given in the issue of ENGINEERING for May 16, 1947, page 397. The firm's display also includes hardness-testing machines for Rockwell, diamond-pyramid and Brinell tests; a pulsator fatigue-testing machine; two dynamic balancing machines for crankshafts and other rotating parts; a dynamic fatigue-testing machine; and a self-indicating spring-testing machine. Most of these machines have been dealt with in ENGINEERING, though it is possible that the examples now on view may contain modifications or improvements.

The exhibit of Messrs. J. Collis and Sons, Limited, 42 and 43, Regent-square, Gray's Inn-road, London, W.C.1, has as its main feature the firm's belt-conveyor, the "MotaVeyor," but, since this was described and illustrated in the account of the British Industries Fair, on page 399 of the issue of ENGINEERING for May 16, 1947, it need not be dealt with again here. An example of Messrs. Collis's 7½-ton lifting truck was also described and illustrated in the same article. The firm's truck, stacker, and RotaVeyor are illustrated by examples at Olympia.

Among the displays devoted exclusively to pumps, that of Messrs. Mono Pumps, Limited, 67, Clerkenwell-road, London, E.C.1, may be mentioned, though briefly, since a typical pump was illustrated and described in our last volume, on page 376 of the issue for May 9, 1947. The present exhibit consists of a number of types of the pump, specially adapted for marine purposes. There is, for example, a pump for marine domestic fresh-water, sanitary and oil-transfer duties; a twin pump for sea-water and bilge handling or for sea-water and fresh-water circulation on Diesel engines; a pump for special duties on submarines, etc. The pump is employed, apart from the more normal purposes, for such unusual duties as pumping brine for refrigerating plant, and in handling the products derived from whale fishing; it is stated that, of the 22 pumps in a whaling factory ship, many are used in the factory part of the vessel. The compact nature of the Mono pump, when used as a water-circulating pump on internal-combustion engines, can be seen by reference to Fig. 23, page 204, which shows, at the forward end of the engine, two such pumps, one above the other. They may be identified by the lower pump having "broken off" pipes.

Of the engines displayed on the stand of Messrs. Davey, Paxman and Company, Limited, Standard Ironworks, Colchester, that illustrated in Figs. 22 and 23, page 204, has been selected for description. The engine is classified by the makers as a Mark 5.RWM marine oil engine, and is of the four-stroke cycle type, with five cylinders, 5½ in. bore by 7 in. stroke. At 1,000 r.p.m., the engine rating is 100 brake horse-power, and at 1,250 r.p.m. the rating is 120 brake horse-power. These figures apply to normal continuous operation, but for occasional intermittent service the engine is capable of developing 140 brake horse-power at 1,500 r.p.m. Fig. 22 shows the after end of the engine and Fig. 23 the forward end; in both illustrations it should be noted that the dark base is merely a temporary structure representing the engine seating. This structure hides the lower part of the engine bedplate. This is of cast iron and also forms the sump. It carries the main bearings, which are steel shells lined with white-metal. The junction of the bedplate and cylinder block is at the crankshaft centre line, the cylinder block consisting of one casting with water-jacketed cylinders having dry-type liners. The camshaft is housed in the upper part of the cylinder block in a circular "tunnel," on bush-type bearings, and runs in an oil bath; it is driven from the crankshaft by a triplex chain. The cylinder head consists of two castings, one containing two sets of valves and the other three sets. The rocker gear is enclosed by a cover which, as will be evident from the illustrations, also embodies the air inlets. The heads have the well-known Ricardo spherical antechambers into which single-hole pintle-valve injectors are led at an angle, as can be seen in Fig. 22, and identified by the delivery pipes leading to them from a grouped fuel pump, which is driven through gears by the main camshaft. The drive also incorporates the high-speed centrifugal governor, which is adjusted by the hand lever visible in Fig. 22.

Immediately below the governor assembly in this illustration is a housing, separate from the crankcase, for the flywheel, with the casing for the reverse and reduction gear to the left. The standard engine is fitted with a mechanically-operated reverse gear of the planetary spur-gear type. The speed reduction is either 2 to 1; 2½ to 1; or 3 to 1, as desired. The engine can be supplied, alternatively, with a direct drive. The engine is pressure-lubricated throughout, the pump being of the valveless gear type. The hand pump visible in Fig. 22 is for the initial priming of the lubrication system. Above it is the 24-volt starting motor. A lighting dynamo can be seen at the forward end. The drive to the dynamo is visible on the left of Fig. 23, the similar casing next to it covering the drive to the pair of Mono pumps, the upper one of which is for the cooling-water circulation. The pump delivery is to the jacket of the exhaust manifold, from the end of which a pipe leads to the cylinder-jacket manifold; the suction is through an oil cooler. The lower of the two pumps is a bilge pump. The pumps, it will be remembered, are of the positive-displacement type, in which a metal rotor having a helical contour, not unlike a worm of very coarse pitch, is rotated in a stator of natural or synthetic rubber with an internal contour of two grooves forming a double helix of twice the pitch of the stator. The rotor maintains a constant seal in the stator, and since this seal travels axially along the body of the pump, it produces a uniform displacement resulting in a suction effect at one end of the pump and a delivery effect at the other. Other engine exhibits on Messrs. Davey Paxman's stand include an example of the smallest unit in the firm's range, namely, the Mark 4.RQ four-cylinder vertical Diesel engine, with cylinders 4½ in. by 5½ in. stroke, developing 44/60 brake horse-power at speeds of 1,000/1,500 r.p.m.; and the Mark 6.RPL six-cylinder vertical Diesel engine, with cylinders 9½ in. bore by 12 in. stroke, developing 336/420 brake horse-power at 600/750 r.p.m.; or in the pressure-charged form 450/562 brake horse-power at the same speeds. A sectional model of the 12.RPH V-type Diesel engine is shown and it is interesting to note that this V-model can be used with one bank of six cylinders only, which means that, should it be subsequently desired to double the output of the "in-line" engine thus formed, the second bank of six cylinders can be added.

Although the Diesel-engine generating set seen in Fig. 24, page 204, has been selected for illustration from the exhibit of the National Gas and Oil Engine Company, Limited, Ashton-under-Lyne, and is intended for service as a marine auxiliary, the display of this firm also includes several examples of marine-propulsion units. The set has a five-cylinder engine of the "D.A." type, which develops 45/50 brake horse-power at 1,000 r.p.m. and drives directly a 400-volt, three-phase alternator having its exciter placed above the generator and driven by Texrope from the generator shaft. The minimum fuel-oil consumption is 0·35 lb. per brake-horse-power-hour. This type of engine is notable for the complete enclosure of all working parts. The cover seen below the cylinder-head casting has three panel-type air filters; underneath it is the cover for the electric starter and the dynamo, and is identified by a push-button starter and an ammeter at the centre; below that is the front crankcase cover. The crankshaft is of underslung type, and, by removal of the front and rear crankcase covers, the pistons can be withdrawn from the side of the engine. The box-like structure on the right-hand end of the engine is a duplex Lolos filter on the delivery side of the lubricating oil gear-type pump; the small cover immediately to the left of the filter gives access to a spiral-tube oil cooler. The fuel-oil inlet is just above this cover, and the opening lower down in line with it is the circulating-water inlet; the outlet is visible on the cylinder-head cover, with the exhaust outlet behind it.

Possibly, however, the most unconventional engine on this stand is a "M4AM6" type six-cylinder Diesel marine-propulsion engine, developing 200/220 brake horse-power at 1,200 r.p.m. and having oil-operated reverse-reduction gearbox. This engine has four valves per cylinder actuated from two camshafts. The valves are arranged on both sides of the engine, and have individual tangential ports, so that a swirl is promoted in the cylinder conducing to high efficiency. The arrangement involves twin air inlet and exhaust manifolds. The crankshaft, as is the general practice with the firm's designs, is large, the diameter of the journals and pins being equal to 75 per cent. of the piston diameter. The material of the shaft is either alloy steel, heat-treated to give a Brinell hardness number of 250, or is of an acicular type of cast iron having an ultmate tensile strength of 30 tons per square inch. One cast crankshaft is to be seen on the stand. The alloy pistons are notable, being pressed from a casting so that a structure combining the advantages of forging and casting results. Each of the two camshafts operates one inlet and one exhaust valve of each cylinder; one of these shafts also actuates the fuel pumps and the governor, the other operates the compressed-air distributor. The lubricating-oil pump and two circulating pumps are driven by a single spiral-bevel wheel on the crankshaft, any of which pumps can be readily removed without affecting the other two. The lubricating-oil system has a somewhat elaborate filtering system comprising a suction strainer, an Auto-Klean strainer and three Streamline filters, the latter being embodied in the crankcase doors. The oil-operated reverse-reduction gearbox on the engine exhibited has been supplied by Messrs. Modern Wheel Drive, Limited, 15, Dartmouth-street, London, S.W.1. It is stated that, by changing over an oil cock connected to the engine speed control, reversal can be effected in about 6 seconds without shutting down the engine.

On the two stands occupied by Messrs. W. H. Allen, Sons and Company, Limited, Queen's Engineering Works, Bedford, are examples of various types of independent and combined units comprising Diesel engines, steam turbines, steam engines, pumps, direct-current generators, motors, control gear and switchgear. Clearly, it is impracticable to describe the whole of this wide range of products in detail, so that only two representative examples are dealt with here. The first of these, illustrated in Fig. 25, page 204, is the 250-kW marine-auxiliary Diesel-engine generating set coupled to a direct-current dynamo of the firm's manufacture. The engine has five cylinders and develops 365 brake-horse-power at 410 r.p.m.; it is of the four-stroke airless-injection type with the cylinder formed in a single casting bolted to a deep crankcase and bedplate having large access doors on both sides. The engine and generator are assembled on a common fabricated bed. Some detail features are that the exhaust valves, of heat-resisting steel, are carried in detachable water-jacketed cages, while the inlet valves are provided with renewable seatings of a special cast iron. Although scarcely distinguishable in Fig. 25, there is a separate fuel pump for each cylinder near the valve tappet rods, this arrangement permitting the pump to be located close to the injector concerned, with short delivery pipes. The adjusting gear of the centrifugal-type governor enables the engine speed to be varied while running. The camshaft is driven by a silent-running duplex roller chain from the flywheel end of the crankshaft, and the case-hardened steel cams operate the valve levers which are short since the gear is overhead; the lever spindles are mounted in ball bearings.

The direct-current generator is designed primarily for marine use with Diesel-engine drive, the windings, for example, being impregnated with materials selected to meet the conditions prevailing on ship-board. The armature is of unusually rigid con-

struction, and is formed with a solid coupling for bolting directly to the face of the engine flywheel, the commutator being a separate assembly driven by keys from the armature spider. Individual brushes are fitted and are carried in separate radial boxes attached to serrated surfaces on very rigid arms. The arms are supported by, and insulated from, a rocker, the whole assembly providing for adjustment of the pressure and position of the brushes. The magnet system consists of a low-carbon rolled-steel yoke with laminated main poles and low-carbon steel interpoles attached to it by locked screws. The field and interpole windings are wound on a former and can be readily removed, complete with their insulation, from their respective poles. The machine is compound-wound with series windings on the negative side of the armature. The machine frame is split on the centre line to facilitate erection and dismantling, the single pedestal bearing being similarly designed. The bearing is pressure-fed from the engine lubricating system, precautions being taken to prevent oil creep along the armature shaft. A drip canopy is fitted over the dynamo and it is adequately protected by guard rails, both of which are necessary precautions on shipboard. It may be noted that, for photographic purposes, the guard rails, with the exception of two of the stanchions, have been removed.

The second typical example selected for illustration is the motor-driven auxiliary pumping unit shown in Fig. 20, on this page. It consists of a vertical-spindle centrifugal pump having a suction branch 20 in. in diameter and a delivery branch 18 in. in diameter, the general design being of the firm's standard double-suction type. The pump is capable of handling 6,500 gallons of water per minute against a head of 30 ft. when running at a normal speed of 650 r.p.m. The driving motor is of the enclosed-ventilated drip-proof pattern. It is continuously rated at 78 h.p., the speed range being from 430 r.p.m. to 650 r.p.m.; it runs on 220-volt direct current. The pump spindle is flexibly connected to the rotor spindle, the downward pull arising from the weight of the rotating parts of the pump being taken by a ball bearing, with a spherical seating, arranged at the top. The bearing at the bottom of the pump is of a type resulting from experience gained with similar machinery on board ship. It is the water-lubricated "Railko" fabricated bush, which has an asbestos base impregnated with colloidal graphite and synthetic resin, and is compressed initially to a high density. The pump gland is fitted with United States metallic packing, which is lubricated by the sight-feed lubricator visible at the left of Fig. 20. The unit is attached to its seating by feet cast integrally with the pump body. In addition to the pump just described, there is exhibited a steam-turbine driven extraction pump, and a motor-driven salt-water cooling pump. Other exhibits include an 80-kW back-pressure turbo-generator set, two steam-engine driven generating sets of 90-kW and 10-kW output, respectively, and a six-stage turbine-type pump. There is also a 67-h.p. direct-current horizontal-spindle compressor motor, and an open switchboard-type multiple-contactor starting panel designed for use with a 150-h.p. refrigeration compressor on board ship and intended to form part of a sub-switchboard as normally mounted in a refrigeration-machinery compartment. The complete exhibit gives a good idea of the wide range covered by the firm.

An important contribution to safety in harbour navigation is provided by the exhibit of the working parts of an electrically-lighted navigation buoy by Messrs. Chance-Londex, Limited, Anerley Works, 207, Anerley-road, London, S.E.20. This buoy, of which an example is shown in service in Fig. 21, was developed during the war to meet an urgent need for the rapid extinguishing of navigation lights on harbour buoys in the event of approaching enemy aircraft, oil or gas-lighted buoys not proving convenient in this respect. The light in the new buoy was rapidly extinguished, either by switching off by the crews of motor-boat patrols or by a new type of remote control, operated by a push-button on shore. The system has proved so convenient that it is now being adopted by a number of port

THE ENGINEERING AND MARINE EXHIBITION.

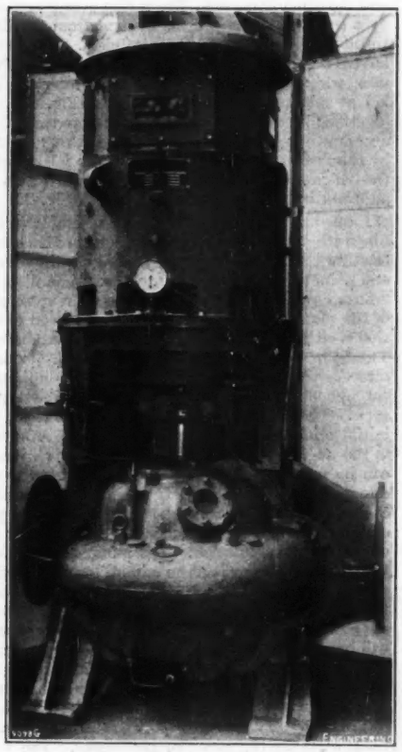


FIG. 20. 18-IN. CENTRIFUGAL PUMP; MESSRS. W. H. ALLEN, SONS AND COMPANY, LIMITED.

authorities, the example illustrated being a buoy in the marking system of the Medway Conservancy Board. The light is derived from an electric accumulator, and the commonly-advanced objection that this normally involves only a short period of service is met in two ways in the Chance-Londex buoy. One of these ways is that the light is of the flashing type and does not burn continuously, the other is that a photo-electric switch prevents the light burning during the day time. The net result is a low consumption of current. This consumption naturally varies with the characteristic of the "flash," but, as an example, it may be said that with a flash of 0·5 second duration and an extinguished period of 10 seconds, the charge in the battery lasts for 670 days, or for 308 days with a flashing characteristic of one second "on" and 10 seconds "off," these figures applying when the special filament lamp is used. The accumulator is taken ashore for recharging, an operation which occupies approximately 24 hours.

The buoy illustrated is not unconventional in appearance. It is surmounted by a cage to form the "day mark." The lantern is seen on the top of the cage, the dark masses inside the cage being the night-day photo-electric switch and the flashing mechanism. The battery may also be carried in the cage, which arrangement is suitable for a shallow-draught buoy; in other cases, say, when a deep-draught gas buoy is converted to electric lighting, the battery is usually housed in the buoyancy chamber. The normal equipment is two all-steel batteries connected in series and contained in a watertight steel box; two wires from it lead to the automatic flashing box, the switch for interrupting the current being actuated by daylight entering through a small window. Two wires lead from the flashing box to the lamp, which is mounted inside a cylindrical lens. The size of the lantern, lens and electric lamp depends on the visibility required, it being stated that a small lens, 100 mm. in diameter, gives a light visible up to a distance of eight miles. The character of

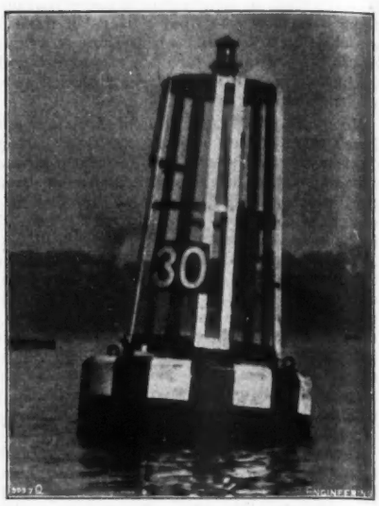


FIG. 21. ELECTRICALLY-OPERATED FLASHING BUOY; MESSRS. CHANCE-LONDEX, LIMITED.

the flash can be varied at will; thus, there can be a number of flashes in quick succession followed by a longer dark period. This possibility of variation is useful where there are a number of buoys together, since individual buoys of the group can thus be made easily identifiable at night. The system is obviously capable of being modified to suit conditions; thus, two sets of two accumulators may be carried if a still longer unattended period is required. On this stand are also exhibited by Messrs. Chance Brothers, Limited, Smethwick, a number of optical lenses of different types, while a land flashing beacon is also shown together with the Londex seadrome landing light equipment, which is shown in operation; this has a green fluorescent light and is operated by a 6-volt accumulator. Londex relays and apparatus are also shown, for the timing of spot and seam welding, for a floatless liquid-level control system, for timing processes in chemical, textile and plastic industries, and for protecting, controlling and counting industrial production.

(To be continued.)

FOIRE DE PARIS.—The next Paris International Trade Fair will be held from May 1 to 17, 1948. Applications for space should be made, not later than December 31, to Miss E. Lambert, 14-15, Rugby Chambers, 2, Rugby-street, London, W.C.1.

BRITISH BRIDGING MATERIAL FOR POLAND.—A total of 11,000 tons of Everall railway bridging material has been sent to Poland by the Ministry of Supply as a gift from the British Government. It is the same type of material as that built by British troops across the Rhine to carry Allied railway traffic.

ARCHITECTURAL AWARD FOR DERBY SCHOOL OF TRANSPORT.—The London Midland and Scottish Railway's School of Transport, Derby, which was designed by the company's architect, Mr. W. H. Hamlyn, F.R.I.B.A., has been awarded the Nottingham, Derby and Lincoln Architectural Society's bronze medallion for the best building erected within the three counties during the period, January 1, 1937, to December 31, 1946.

LECTURES ON GREAT BRITAIN AND LATIN AMERICA.—A series of six lectures, on "Great Britain and Latin America," will be delivered next winter at Canning House, 4, Upper Berkeley-street, Portman-square, London, W.1, under the auspices of the Hispanic and Luso-Brazilian Councils. The lectures which will be held at 5 p.m., on Wednesdays, October 8, November 5, December 3, 1947, and January 7, February 4, and March 3, 1948, deal with Great Britain's contribution to Latin-American economic development, this country's physical connections with Latin America, and other subjects. Further particulars may be obtained from the secretary of the Hispanic and Luso-Brazilian Councils, at Canning House.

"TRENT" PROPELLER-TURBINE AERO ENGINE.

MESSRS. ROLLS-ROYCE LIMITED, DERBY.

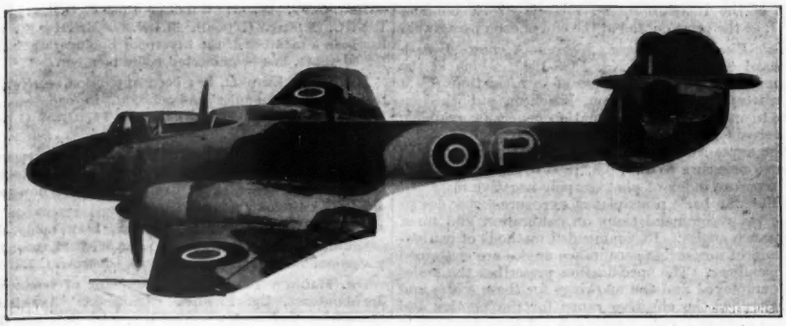


FIG. 1. "TRENT"-ENGINED METEOR AEROPLANE.

FIG. 2. ENGINE UNDER TEST.

ROLLS-ROYCE "TRENT" PROPELLER-TURBINE AERO-ENGINE.

IN the early days of jet propulsion, it was foreseen by Messrs. Rolls-Royce that many new problems would arise when the gas turbine came to be adapted to the driving of a propeller. As the design, from the outset, of an entirely new engine, before a general exploration of the possibilities of this development would have imposed long delay, it was considered that the most profitable procedure would be to modify existing models to enable a general study to be carried out. It is claimed that the first steps towards the evolution of a propeller turbine were taken in the days of the Welland engine, when measurements of shaft horse power were made, these, it is believed, being the first b.h.p. tests ever made on an aero-turbine. The research was followed up by the modification of a Derwent II engine which had a rated thrust of 2,200 lb. The engine was re-fashioned to take a reduction gear and was re-named the Trent. It was first tested in May, 1944, fitted with a reduction gear but no propeller; and in March, 1945, was hangar-tested after fitting with a five-bladed airscrew supplied by Messrs. Rotol, Limited. A view of the engine arranged for hangar test is given in Fig. 2, on this page. Altogether over 1,000 hours of test-bed running have been completed, this period including 400 hours fitted with the Rotol five-bladed propeller.

In collaboration with the Gloster Aircraft Company, two Trent engines were installed in a Meteor Mark I aeroplane, and the first flight of an aircraft powered by an aero-turbine driving a propeller was made in September, 1945, the machine, handled by Wing Commander Heyworth, the Rolls-Royce assistant chief test pilot, taking off from Church Broughton aerodrome. Since that time, many hours of test flying have been carried out and the Trent-Meteor was publicly demonstrated at the International Air Rally at Derby, on June 21. A view of the machine in flight is reproduced in Fig. 1. The modifications to the Meteor aircraft which were made to adapt it to the new engines included a strengthening of the undercarriage and an increase in the throw of the undercarriage legs to give an additional 6 in. of ground clearance for the 7 ft. 7 in. dia. Rotol propellers. The Meteor Mark I aircraft was fitted with stabilising tail fins when undergoing trials at Farnborough. These have been retained in the Trent-Meteor to correct any tendency to swing. The propellers of the machine absorb 750 h.p., and the residual engine thrust is 1,000 lb.

The Trent engine has been developed purely for research purposes and will not be manufactured as a production unit. It is continuing in employment in the general development of aero-turbines, a matter which is being given particular attention being the effect of the propeller hub on air-intake efficiency, tais being an important factor in gas-turbine engines. The reduction gear of the unit consists of three layshafts arranged to carry a double train of gears driven from the compressor, with a final simple reduction gear to the propeller. The overall ratio between the turbine and the propeller is 0·141. The gears used in the first designs were of the plain spur type, but the high contact speed of the teeth set up resonant vibrations which coincided with the natural frequency of the tab washers in the gear-locking devices, with the result that fatigue of these washers occurred and the gear failed. The lay-out has now been re-designed to provide additional strength and a balanced drive, and the trouble has been overcome; the gear now in use has proved entirely dependable after many hours of test-bed running.

Originally, it was decided that the Trent-Meteor should be flown with independent control of the throttle and constant-speed unit, in order to determine what degree of co-ordination between their movements was required, and whether this could be left to the pilot, or the two controls should be linked together and operated simultaneously by a single lever. The first flight trials showed, however, that with completely-independent controls, the pilot required a high degree of skill in order to be able to fly at all. Without correct co-ordination, very rapid changes in thrust were encountered, amounting in extreme cases to negative thrust, and severely upsetting the characteristics of the machine. As a result of its unsatisfactory flying qualities during the initial trials, the machine was grounded for a time. When development was resumed, it was decided, as a temporary expedient, to fit smaller propellers, a diameter of 4 ft. 10½ in. being selected. These absorbed only 350 h.p. The jet-pipe diameter was also decreased, raising the thrust to 1,400 lb. Although these changes made the Trent-Meteor virtually a jet-propelled aircraft, they enabled flight development of the engine to continue and provided useful data for the design of the single-lever control which is now used. With the present arrangement, the constant-speed unit is automatically reset to control at a lower speed when the turbine speed is reduced and the excellent flying qualities of the Meteor have been entirely restored. The Trent-Meteor has now completed well over 80 hours in the air.

CATALOGUES.

Steam-Raising Equipment.—The "Autolec" electrode steam raiser is described in a brochure issued by Messrs. G.W.B. Electric Furnaces, Limited, Dibdale Works, Dudley, Worcestershire. Some typical applications are described and illustrated.

Expanded-Metal Resistances.—A catalogue of their expanded-metal resistances, of nickel-chromium steel and other alloys for industrial, marine and traction applications has come to us from the Expanded Metal Company, Limited, Stanton Works, West Hartlepool, Co. Durham, and Burwood House, Caxton-street, London, S.W.1.

Electroplating Equipment.—Leaflets of their new mains-operated "Easidun" and "Midget" electroplating equipment have been sent to us by Messrs. Runbaken Electrical Products, Burton's Building, 71-73A, Oxford-road, Manchester, 1. With this equipment, it is claimed that good results are obtained by unskilled labour in nickel and chromium plating.

Space Heating and Cooking Equipment.—A technical bulletin (No. 15) issued by the Spirax Manufacturing Company, Limited, Cheltenham, Gloucestershire, deals with methods of draining condensate and venting air from heating, cooking and hospital equipment. The bulletin contains illustrated descriptions of steam traps, heating calorifiers, steam heating systems, kitchen and hospital heating apparatus and other equipment.

Rotary Filters.—We have received from Messrs. Davey, Paxman and Company, Limited, Standard Ironworks, Colchester, a comprehensive catalogue of their rotary vacuum filters. The standard filters described cover 17 sizes, having a range of from 3 ft. in diameter by 1 ft. 2 in. wide with 10 sq. ft. of filter area to 14 ft. in diameter by 16 ft. in diameter with 700 sq. ft. of filter area. The catalogue gives typical materials for which the filters are suitable.

Powder Metallurgy.—Three catalogues are to hand from The Manganese Bronze and Brass Company, Limited, Handford Works, Ipswich, which brochures give various aspects of the applications of powder metallurgy. One of them deals specifically with "Ollite" self-lubricating bronze and lead-bronze bearings; another with "Ollite" sintered metal filters, and another is of a more general nature describing the firm's products in the form of solid and cored bars and in plates and mouldings.

Colliery and Mining Accessories.—Messrs. Hadfields, Limited, East Hecla Works, Sheffield, have recently issued a fully-illustrated catalogue, No. 461, outlining the wide variety of accessories manufactured by them for collieries and mines. These include several types of wheels and axles for tubs and mine cars; wheels, rollers, etc., for conveyor and tub creeper chains; haulage and rope pulleys; coal breakers; prop withdrawers; tub controllers and retarders, mining drill and pick steel tools and so forth.

INSTITUTION ELECTIONS.

INSTITUTION OF CIVIL ENGINEERS.

Associate Member to Member.—Eric Overington Blunden, B.A., B.A.I. (Dublin), Nottingham; William Brown, Birmingham; James Anderson Burnett, Edinburgh; George Vincent Burns, B.Sc. (Eng.) (Lond.), Enfield, Middx.; Frederic Eunson Cormack, C.I.E., B.Sc. (Edin.), London, S.W.1; Norman Stewart Cox, B.Sc. (Eng.) (Lond.), Plymouth; Charles Cyril Rogers Edwards, B.Sc. (Eng.) (Lond.), Rangoon; Arthur Eatough Green, C.I.E., O.B.E., M.C., M.Sc. (Leeds), Patna, India; James Arnold Hood, B.Sc. (St. Andrews), London, N.8; James Henry Jones, Belfast; Walter John Smith Key, Edinburgh; Ralph Henry Lee, G.M., B.Sc. (B'ham), Birmingham; William Linn, Glasgow; Geoffrey McLeod, B.Sc. (Manch.), March, Cambs.; Charles Gerald McNamara, M.Eng. (Nat'l), Dublin; Charles Crommelin Marshall, B.Sc. (Eng.) (Lond.), Rangoon; William Lawrence Docton Martyn, B.Sc. (Manch.), Lahore, India; Harold Robson Metcalfe, Northwood, Middx.; John Abegweit Robertson, B.Sc. (Eng.) (Lond.), B.A.O.R.; James Hoseason Shennan, B.A. (Cantab.), Edinburgh.

Associate Member.—Archibald Paterson Bryce, Edinburgh; Duncan Pratt Joss, B.Sc. (Bristol), Huddersfield; Ernest Robert Muller, B.Sc. (A'deen), Aberdeen; John Storry, B.Sc. (Edin.), Edinburgh.

Student to Associate Member.—Alan Wilfred Bishop, M.A. (Cantab.), London, S.W.20; Walter Alexander Condy, B.Sc. (B'fast), Belfast; Harry Wolstenholme Elton, Southampton; Charles James Mollison, London, N.13; John James Sawers, B.Sc. (Witwatersrand), Johannesburg, Transvaal, South Africa; Saloh Joseph Shamash, B.Sc. (Eng.) (Lond.), London, S.W.7; John Elmer Stevens, B.E. (Nat'l), Ilford.

INSTITUTE OF MARINE ENGINEERS.

Associate Member to Member.—John Cook, Watford; Eric Victor Hartley, Upminster; Leslie Knopp, South Croydon.

Associate to Member.—Ernest Watson Cranston, Wh.Sc., Watford; Ross Morton Dunshea, South Shields; John Garden, Reading; Alan Ruthven, London, E.C.2; Robert Roy Triggs, Goole.

Associate Member.—Lieut. (E) Ronald Gowan Boddie, R.N., Bromley (Kent); John Summersgill, Leeds.

Associate to Associate Member.—Ernest Harold Duncan, Forest Gate.

CONSUMPTION OF COPPER IN UNITED KINGDOM.—Industrial statistics prepared by the British Non-Ferrous Metals Federation, 132, Hagley-road, Birmingham, 16, show that the July output of copper, contained in unalloyed and alloyed copper products and in copper sulphate, totalled 46,779 tons. Of this, 28,895 tons consisted of virgin copper and 17,884 tons of scrap. The aggregate for unalloyed copper rods and sections, strip and sheet, tubes, castings and other products was 26,801 tons for the month. The copper content of the brass, bronze, and other alloy wire, rods, sections, strip, sheets, tubes and castings was 19,209 tons and the copper used for making copper sulphate was 769 tons.

THE EXPORT OF SECOND-HAND STEEL TUBES.—The Iron and Steel Board are concerned about the unauthorised exports of second-hand tubes, and in particular, locomotive seamless boiler tubes, capable of being used again. The Ministry of Supply announce that all holders of HH/2HD licences have been notified, by a circular letter dated July, 1947, that the acquisition and disposal of all second-hand steel tubing is governed by the same general principles as new tubes. That is to say, that such tubes having been acquired on the authority of an HH/2HD licence, they can only be disposed of against the quotation of departmental symbol, contract and period number, authorised on Form "M," or to persons who, being themselves holders of an HH/2HD licence, quote that licence number on their order. The only qualification to this general procedure is the case of a person who takes advantage of the small-quantities exemption provisions of the Control of Iron and Steel Order, and furnishes the necessary certificate. The effect of this is that no second-hand tubes may be exported except by sanction of a disposal licence issued by the Iron and Steel Board. The fact that it is unnecessary to obtain a Board of Trade export licence does not relieve the licensee or exporter of the obligation to obtain authority to export from the Iron and Steel Board. Notwithstanding that the Control Orders are binding on all licensees and second-hand dealers, it is stated that unauthorised shipments have, in fact, occurred. The Board take a serious view of the matter, and licensees are warned that non-observance of the Orders may lead to the withdrawal of the HH/2HD licence and to proceedings.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Photo-Electric Exposure Meters.—A new British Standard Specification, No. 1383-1947, which is the outcome of a wide programme of investigations by a committee of the Institution, has been published in order to make certain information generally available as a basis for the future development of photo-electric exposure meters. The new publication, which requires reference to B.S. No. 1380 covering the speed and exposure index of photographic negative material, describes the basic principles of exposure-meter design and gives recommendations on calibration and upon acceptance angles. Recommended methods of calibration and of measuring acceptance angles are contained in appendices. The specification prescribes the scales to be employed and the markings for these scales and also specifies the effective range for the pointer and the standard of accuracy required. A limit for time of response and limits for errors owing to fatigue due to tilting or to change in temperature are also included. [Price 2*s.*, postage included.]

Metal Lathing for Plastering.—Another new specification, B.S. No. 1369-1947, covers metal lathing (mild steel) for plastering. It has been prepared at the request of the Codes of Practice Committee for Civil Engineering, Public Works, Building and Constructional Work, and concerns five types of mild-steel lathing. These are (*a*) plain expanded metal; (*b*) ribbed expanded metal with the ribs forming an integral part of the expanded sheet; (*c*) ribbed expanded metal with the ribs attached subsequent to the expansion of the sheet; (*d*) perforated sheet; and (*e*) dovetailed sheet. It is stipulated that the blank sheet from which the lathing is made shall be of mild steel, sufficiently ductile for the manufacture of the finished product and without flaws or defects. Methods of manufacture are specified for each type, and clauses relating to the material, the size of the mesh, the minimum weight of the sheet, and tolerances on the size and the weight of the sheet, are included. It has not been possible, at present, to standardise the sizes of the sheets, but maximum and minimum lengths have been laid down. [Price 1*s.*, postage included.]

BOOKS RECEIVED.

The Association of Special Libraries and Information Bureaux. Report of ASLIB Meeting on Industrial Information Services, 8 May, 1946. Offices of the Association, 52, Bloomsbury-street, London, W.C.1. [Price 3*s.* to members of the Association; 4*s.* to others.]

Mitteilungen aus dem Institut für Strassenbau an der Eidgenössischen Technischen Hochschule in Zürich. No. 4. ***Beanspruchung von Strassenbelägen durch metallische Systeme (Ersatzbereifung, Raupe, Walze, Wagenrad, Pferd).*** By DR. SC. TECHN. ERNST ZIPKES. A.-G. Gebr. Leemann & Co., Stockerstrasse 64, Zürich 39. [Price 25 Swiss francs.]

Ministry of Fuel and Power, and British Intelligence Objectives Sub-Committee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 14. ***A New Type of Main Road Battery Locomotive.*** By DR. ENGR. A. WEDDIGE. [Price 9*d.* net.] Appendix No. 15. ***Comparison of Locomotive Costs.*** By PROFESSOR DR. ING. HEINRICH KOCH. [Price 6*d.* net.] Appendix No. 17. ***Standardisation of Pit Tubes.*** By DR.-ING. RER. POL. ERICH SCHLOBACH. [Price 1*s.* net.] Appendix No. 19. ***Development Possibilities of Large Mine Cars.*** By DIPL. ENGR. H. SCHÄFER. [Price 9*d.* net.] Appendix No. 22. ***Methods of Fitting Winding Ropes and Balance Ropes.*** [Price 9*d.* net.] H.M. Stationery Office, Kingsway, London, W.C.2.

An Anthology of Clocks and Watches. Selected and edited by DR. C. A. O. FOX. Dr. C. A. O. Fox, Valley House, Bishopston, Swansea. [Price 8*s.* 6*d.*]

A Dictionary of Mathematics: Arithmetic and Algebra. By C. H. MCDOWELL. Mathematical Dictionaries, 72, Victoria-street, Westminster, London, S.W.1.

Department of Scientific and Industrial Research. Road Research Laboratory. Road Research Technical Paper No. 7. ***Impressions of Roads and Road Research in North America.*** H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

Textbook of Illuminating Engineering. (*Intermediate Grade.*) By DR. J. W. T. WALSH. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 17*s.* 6*d.* net.]

Power Station Efficiency. By C. W. PRIEST. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 10*s.* 6*d.* net.]

PERSONAL.

MR. J. C. MARTIN, O.B.E., M.I.C.E., retired from the staff of the Chief Engineer's Department, London Passenger Transport Board, 55, Broadway, London, S.W.1, on August 20.

ENG.-CAPT. W. J. WILLETT BRUCE, O.B.E., R.D., R.N.R., M.Eng. (L'pool), M.I.N.A., M.I.Mar.E., who has been a member of the Liverpool Engineering Society for 50 years, has been elected a life member.

MR. M. A. LIDDELL has been appointed secretary of the Water Companies' Association, in succession to MR. C. CROWTHER. His address is 15, Great College-street, London, S.W.1.

MR. C. B. GLENESK, A.M.I.C.E., who has been engineer in charge of the London and North Eastern Railway Manchester District since April, 1944, has now been appointed district engineer, Glasgow.

MR. MAURICE MILNE, B.Sc., has been made chief assistant to Messrs. D. A. Donald and Wishart, consulting engineers, 233, West Regent-street, Glasgow, C.2.

DR. MAGNUS TIGERSCHIÖLD, director of research of Jernkontoret, the Swedish Ironmasters' Association, Stockholm, has been awarded a special Bessemer Gold Medal by the Council of the Iron and Steel Institute. It will be presented by the President, Dr. C. H. Desch, F.R.S., during the two-hundredth anniversary celebrations of the foundation of the Association, to be held in Stockholm on September 5 and 6.

MR. DAVID ARNOTT, vice president and chief surveyor of the American Bureau of Shipping, 45, Broad-street, New York, 4, retired as an active officer of the Bureau on July 31, but will continue to act in a consultative capacity. MR. D. P. BROWN has been appointed to succeed Mr. Arnott as chief surveyor.

MR. G. E. ROBERTS, A.M.Inst.W.E., has relinquished his appointment as water engineer and manager to the Spalding Urban District Council and has taken up the appointment of water engineer to the Pontypridd and Rhondda Joint Water Board.

MR. G. A. GEACH is leaving the staff of the research department of Metropolitan-Vickers Electrical Company, Limited, to join that of the research laboratory of Associated Electrical Industries, Limited, Reading.

MR. J. B. SCOTT, A.M.Inst.W.E., is to succeed MR. LEWIS COSTLEY, M.Inst.W.E., as burgh surveyor and water engineer of Motherwell and Wishaw.

MR. E. H. F. STONE has been moved to the Witton, Birmingham, research department of Imperial Chemical Industries, Limited, Metals Division, after five and a half years at the Swansea works of the company.

MR. W. J. TYDEMAN, A.M.I.Mech.E., has been appointed advertisement manager of the McGraw-Hill journal, *The Machinist*, and will take up his duties next month.

MR. C. W. MORLEY has relinquished his position on the staff of High Duty Alloys, Limited, Slough, to join the British Scientific Instrument Research Association.

The Colonial Office announce that MR. W. M. HOLLANDS has been appointed an executive engineer, Gold Coast, and MR. D. G. VINELL a drainage and irrigation officer, Malaya.

MR. F. F. GORDON, Assoc.Met.(Sheffield), has been appointed a managing director of Messrs. Spear and Jackson, Limited, Aetna Works, Sheffield.

MR. F. G. W. TREE, A.M.I.E.E., of Glasgow, has been appointed lighting engineer for Scotland, for Thorn Electrical Industries, Limited.

MR. DAVID WATT, B.Sc., M.I.E.E., has been appointed sales manager (home) of Lancashire Dynamo and Crypto, Limited. He has been London sales manager of the firm for the past four years and will continue to operate from 94, Petty France, London, S.W.1.

MR. N. READMAN, A.C.A., the secretary, and MAJOR R. E. L. IZOD, T.D., have been elected directors of the Consolidated Pneumatic Tool Company, Limited, 233, Dawes-road, London, S.W.6.

MR. F. E. STOCKELD has been elected President and MR. W. E. BALLARD, vice-president of the Birmingham Metallurgical Society for the session 1947-48.

MR. J. E. ROBERTS, B.Eng. (L'pool) is joining the English Electric Company, Limited, Stafford.

MESSRS. THE P.D.N. CASTLE ENGINEERING COMPANY' LIMITED, 87, Pembury-road, Tottenham, London, N.17, have been appointed sole agents for MESSRS. GEORGE CLARKE PRESSWORK COMPANY, LIMITED, 1, Park Street-terrace, Wednesbury, Staffordshire, for the sale of their products in London and the South East of England.

THE STURTEVANT ENGINEERING COMPANY LIMITED, are closing their emergency offices at Sutton and Aylesbury and will open new headquarters at Southern House, Cannon-street, London, E.C.4 (the old Cannon-street Station Hotel), on September 5. The telephone number will be MANsion House 0533 and the telegraphic address, Sturtevant London.

NOTES FROM THE NORTH.

GLASGOW, Wednesday,

Scottish Steel.—It has been reported that the steel output from the works in the West of Scotland last week touched a higher level than any witnessed for many years—an exact comparison figure is not available, but experts connected with the steel industry here say that last week was the best for at least 18 to 20 years. In effect, the output level last week was slightly over 40,000 tons of ingots and castings, which compares with a weekly average output of 34,000 tons last year. In view of the extraordinary climatic conditions prevailing last week, the performance is distinctly praiseworthy. One big steel combine actually exceeded what had been regarded as its maximum effective capacity of production. Notwithstanding this effort, the demand was still unsatisfied. Plates were notably scarce in sizes between $\frac{1}{4}$ in. and $\frac{1}{2}$ in., while many sections and bar products were almost as difficult. The British Iron and Steel Control are understood to be greatly concerned about the shortages in light plates. Sheet bars and billets were again in light supply and re-rollers found it impossible to expand production beyond the level of a two-shift output, and not always even a full two-shift output. Galvanised and black sheets continued to be sparsely allocated, the bulk of material being absorbed in meeting high-priority contracts. The position of steel scrap is causing anxiety more especially as pig-iron production is likely to be affected by difficulties in procuring metallurgical coke in sufficient quantity. Cast-iron scrap is even scarcer than steelworks scrap, while plant and machinery scrap is most difficult to obtain.

Scottish Coal.—Outputs are falling instead of rising owing to a persistently high degree of absenteeism and the outbreak of unofficial strikes in various parts of the coalfield, mainly in the Lanarkshire area. Current needs have been covered, but the progress to be expected during a hot summer is far from being realised. Scotland's stocks are well behind the target in many departments, and the collieries are reporting a steady falling off in enthusiasm among the men, so that the prospects of catching up again are receding. Export supplies are quite nominal. The price demanded for an extra effort by the men is such that the Coal Board are showing more "toughness" than on previous occasions.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—More regular supplies of blast-furnace coke have lessened anxieties at the furnaces and ensured a more satisfactory flow of pig iron. Now that works holidays have come to an end, the production of steel has been increased a little with the help of fuller supplies of gas for melting and heat-treatment. Gradually, as foreign labour becomes attuned to work at the rolling mills and forges, there is some small improvement in the supply of sheets and bars. Work has been resumed on the conversion of steel plants from coal to fuel oil, and at the Steel, Peech and Tozer branch of the United Steel Companies at Templeborough, it is computed that, by the end of the year, eight of the 14 open-hearth steel furnaces will be operating on oil. This will effect a saving in coal consumption of 150,000 tons a year. Later it is intended to convert two furnaces to the consumption of creosote pitch. Work on a considerable number of orders placed for iron and steelworks plant and machinery at the works of Davy and United Engineering Company, Limited, is proceeding. Designing staff has been augmented to cope with the greatly expanding volume of business. Further orders are coming to hand for railway materials to add to the already congested order books. Factories producing edge and other tools are booked for many months ahead.

South Yorkshire Coal Trade.—Further pit holidays were started last week-end when Barnsley Feast opened. Supplies of coal will consequently be restricted by these authorised breaks as well as by the unofficial stoppage at Grimethorpe which has entailed a loss of about 30,000 tons of coal. Progress of the programme of building up stocks for the winter has consequently been slowed down. It has been possible to maintain fairly satisfactory deliveries to gas and electricity works, and to provide the fuller quantities of coking coal at N.C.B. ovens. House coal has been quieter, and some additions to stocks, in some instances, have been at the expense of deliveries to householders.

L.M.S. RAIL-CARRYING WAGONS.—The London Midland and Scottish Railway Company have recently purchased, from the Ministry of Supply, fifty 50-ton ex-War Department Warwell wagons for carrying steel rails for permanent-way renewal programmes. Four bolsters have been fitted to each vehicle, necessitating building up the well to the same height as the remainder of the vehicle, and they now have a capacity of 30 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Trading in Welsh steam coals has continued actively throughout the past week, but sellers have again only had restricted quantities to deal with. Every quality has remained in extremely short supply, and although a fairly steady level of output has been reported generally there was no sign of any easing in the position. All customers were eager for the largest possible deliveries, and standing contracts continued very largely to absorb available supplies. Consequently, sellers were not in a position freely to entertain fresh bookings and the amount of new business that could be placed was limited. Practically the entire output moved inland, where the demand was maintained at as high a level as ever, and a very careful watch was kept over all orders to ensure the fairest possible distribution. Only very occasional releases were made for special priority purposes abroad and although numerous overseas buyers maintained a steady interest they could not obtain any satisfaction. Very brisk conditions ruled for cokes but, owing to past heavy sales, producers could not handle a great deal of new business. Patent fuel continued to find a ready market and was firm. Agreement has been reached in the dispute with colliery winding-engine men and the strike notices have been withdrawn.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, there was no change in the condition of the tin-plate industry. Matters remain quiet in regard to new business. Makers have well-filled order books and are unable to take on any appreciable quantities for the current quarter. At the present time, production has been affected by the prevailing hot weather. In the export market conditions are quiet, although a slightly increased volume of business has been transacted. Steel sheets are in great request and the delivery of orders other than priority is likely to be long deferred. Iron and steel scrap, more particularly the heavier descriptions, are in strong demand by the steelworks and foundries.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The output of Cleveland ironstone is still at a low level necessitating continued heavy imports of high-grade foreign ore. The shortage of pig-iron continues and all available parcels of iron and steel scrap are promptly taken up. Iron and steel producers are sold as extensively as conditions permit, but priority customers are clamouring for greater supplies of commodities urgently needed in very large quantities for home purposes and for shipment overseas. Higher outputs of foundries and furnaces are essential to meet pressing requirements. The fuel supply is still precarious, but if the larger deliveries promised come to hand, consuming plants will speedily be more actively engaged than for the past two months, during which period the total tonnage output of iron and steel fell considerably short of expectation. An additional blast-furnace has been blown in and more idle stacks are to be re-kindled in the Tees-side area as adequate coke supplies become available.

Foundry and Basic Iron.—Acute shortage of high-phosphorus pig-iron continues gravely to hamper operations at consuming plants, but, while obstacles to expansion in production are still formidable, the hope of an increase in output in the near future is entertained. There is no basic iron on the market. The whole of the output is absorbed by the requirements of makers' own consuming plants.

Hematite, Low Phosphorus and Refined Iron.—The limited make of East-Coast hematite is steadily absorbed and outputs of low and medium phosphorus grades of iron fall inconveniently short of current needs. The demand for refined iron is considerable and manufacturers have no difficulty in disposing of their supplies.

Manufactured Iron and Steel.—Semi-finished and finished-iron firms have contracts to carry out which will keep their works very actively occupied for some time, the demand for steel semies exceeds production capacity, but every effort is being made to bridge the gap. Further import of Continental material is eagerly awaited. Pressure is greatest for larger deliveries of small billets and sheet bars to the re-rolling mills. Firms turning out finished descriptions of steel have enormous commitments and are unable to cope with home and overseas customers' persistent calls for increased deliveries. Plate producers, sheet makers, manufacturers of joists and sections, and firms supplying railway requisites are fully sold and have to delay supplies to priority buyers.

Scrap.—Good heavy steel scrap is in very strong request and the various grades of cast iron scrap are in brisk demand.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

BRITISH ASSOCIATION.—*Section G (Engineering):* Friday, August 29, Monday, September 1, and Tuesday, September 2, at 10 a.m. each day, at University College, Dundee, various papers and discussions. Visits to works, etc., each afternoon. For programme, see page 159, *ante*.

INSTITUTION OF PRODUCTION ENGINEERS.—*Luton Section:* Monday, September 8, 7 p.m., Town Hall, Luton. Film Display, introduced by Mr. W. Whitworth Taylor.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, September 9, 5.30 p.m., 85, Minories, E.C.3. (i) Presidential Address, by Sir Amos L. Ayre. (ii) "Steam Pipework Design in Ships," by Lieut. (E) P. T. Hoath.

ROYAL AERONAUTICAL SOCIETY.—Tuesday, September 9, 7 p.m. for 7.30 p.m., Guildhall, E.C.2, Dinner in honour of the Anglo-American Aeronautical Conference.

LAUNCHES AND TRIAL TRIPS.

S.S. "NIGERIAN."—Single-screw cargo vessel, built by the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, to the order of the United Africa Company, Limited, London. Main dimensions: 415 ft. by 56 ft. 6 in. by 37 ft. 2 in. to shelter deck; deadweight capacity, 8,000 tons on a draught of 24 ft. Triple-expansion engine of reheat design supplied by the North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne. Launch, August 19.

R.M.S. "PRETORIA CASTLE."—Twin-screw passenger and general cargo vessel, built and engined by Messrs. Harland and Wolff, Limited, Belfast, for the Union-Castle Mail Steamship Company, Limited, London. Main dimensions: 750 ft. overall by 83 ft. 6 in.; gross tonnage, about 28,500. Accommodation for 250 first-class and 500 cabin-class passengers. Two sets of Parsons-type geared turbines with three Babcock and Wilcox water-tube boilers. Launch, by radio-telephony from South Africa, August 19.

S.S. "FEDERICO SCHWAGER."—Single-screw vessel for the carriage of coal or iron ore, built by Messrs. William Gray and Company, Limited, West Hartlepool, for the Compañía Carbonífera y de Fundición Schwager, Valparaiso. Main dimensions: 415 ft. by 57 ft. 6 in. by 32 ft. 6 in. to upper deck; deadweight capacity, about 9,000 tons on a draught of 25 ft. Triple-expansion engine supplied by Messrs. George Clark (1938), Limited, Sunderland, to give a service speed of 10½ knots. Launch, August 19.

S.S. "LORELLA."—Trawler, built by Messrs. Cook, Welton and Gemmell, Limited, Beverley, East Yorkshire, for Messrs. J. Marr and Son, Limited, Fleetwood. Main dimensions: 166 ft. 9 in. by 29 ft. by 15 ft. 3 in. Reciprocating machinery supplied by Messrs. Charles D. Holmes and Company, Limited, Alfred-street, Hull, to give a loaded trial speed of 12 knots. Launch, August 20.

THE IRON AND STEEL INSTITUTE.—The Council of the Iron and Steel Institute have decided that members of 50 years' standing shall, in future, become life members without further payment. This ruling will take effect from January 1, 1948. Eleven members will have completed 50 years' membership by the end of the present year, in addition to five who hold honorary positions.

DIGEST OF ARTICLES ON DIAMONDS.—The Industrial Diamond Information Bureau, Industrial Distributors (1946) Limited, St. Andrew's House, 32-34, Holborn Viaduct, London, E.C.1, publish monthly a bulletin containing abstracts of articles dealing with the properties and industrial applications of diamond. Notices of patents and patent applications in many countries are also included. A copy of the bulletin may be obtained, gratis, on application to the above address.

EXHIBITION OF "PHOTOGRAPHY IN INDUSTRY" ON TOUR.—The exhibition of applied photography, recently organised in London by Kodak Limited, is to tour the Provinces. It will be held at the People's Hall, Albion-street, Leeds, from September 8 to 12; at 244, Deansgate, Manchester, from September 29 to October 3; at McLellan Galleries, Sauchiehall-street, Glasgow, from October 13 to 17; at the Chamber of Commerce, Birmingham, from October 27 to 31; and finally at the City Museum, Queen's-road, Bristol, from November 10 to 14. The times of opening are from 10 a.m. to 5.30 p.m., and admittance is by invitation, to be obtained from the Industrial Sales Department, Kodak Limited, Wealdstone, Harrow, Middlesex. The exhibition, however, will be open to the public on one day at each centre.

EXHIBITS AT THE ENGINEERING AND MARINE EXHIBITION.

(*For Description, see page* 193.)

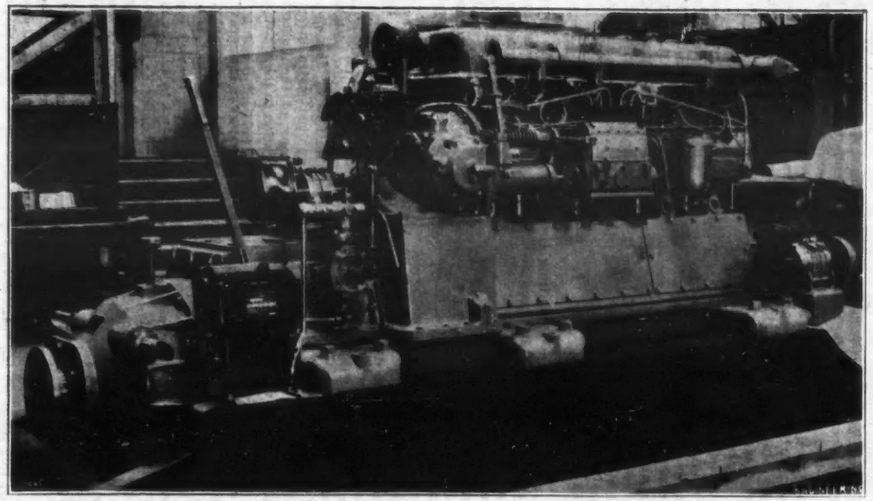


FIG. 22.

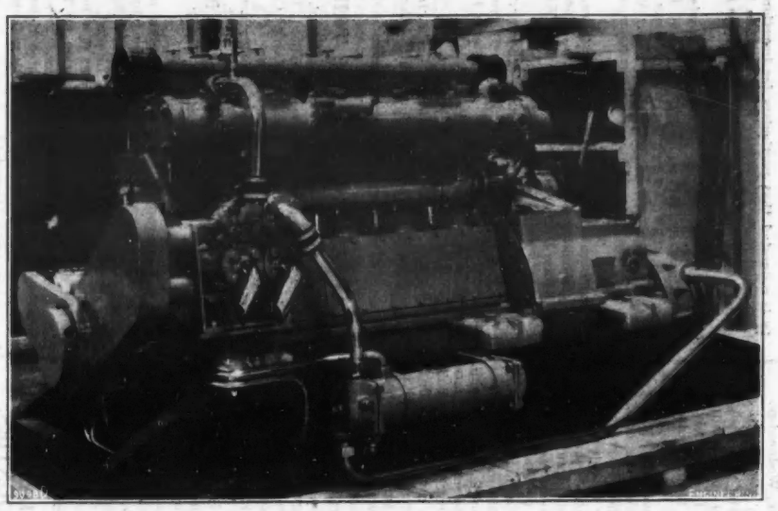


FIG. 23.

FIGS. 22 and 23. FIVE-CYLINDER 100/140-B.H.P. MARINE OIL ENGINE; MESSRS. DAVEY, PAXMAN AND COMPANY, LIMITED.

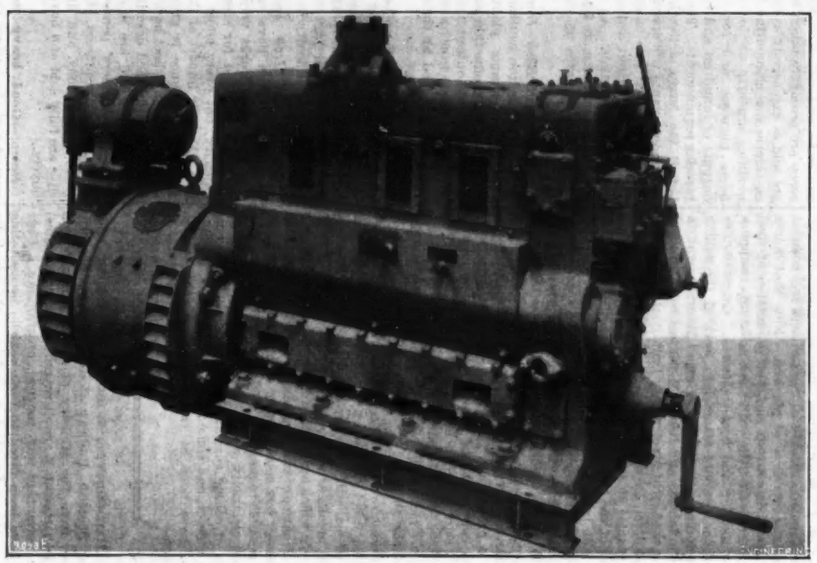


FIG. 24. FIVE-CYLINDER 45/50-B.H.P. DIESEL-ENGINE GENERATING SET; THE NATIONAL GAS AND OIL ENGINE COMPANY, LIMITED.

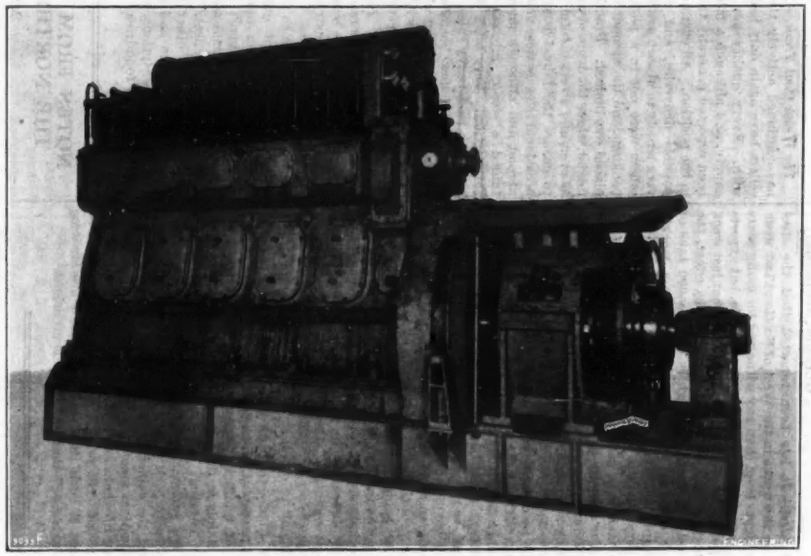


FIG. 25. FIVE-CYLINDER 365-B.H.P. MARINE AUXILIARY DIESEL-ENGINE GENERATING SET; MESSRS. W. H. ALLEN, SONS AND COMPANY, LIMITED.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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SUBSCRIPTIONS.

"ENGINEERING" may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance:—

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For Canada	£4 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

CONTENTS.

	PAGE
Engineering and Marine Exhibition at Olympia (*Illus.*)	193
Rolls-Royce "Trent" Propeller-Turbine Aero-Engine (*Illus.*)	201
Catalogues	201
Institution Elections	202
British Standard Specifications	202
Books Received	202
Personal	202
Notes from the North	203
Notes from South Yorkshire	203
Notes from the South-West	203
Notes from Cleveland and the Northern Counties	203
Notices of Meetings	203
Launches and Trial Trips	203
Speed on Railway Curves	205
Power from the Wind	206
Notes	207
Babbitt Alloys for Main Bearings (*Illus.*)	208
The "Model Engineer" Exhibition	209
Letter to the Editor.—Effect of Centrifugal Force in Axial-Flow Turbines	210
Obituary.—Mr. Walter Pollock. Mr. Roy Chadwick. Mr. W. Southworth	210
Progress in Modern Engineering	210
The Work of the Royal Institution in Physical Chemistry	211
Labour Notes	212
Analysis of the Position in Soil Mechanics (*Illus.*)	213
Low-Carbon Molybdenum Steel	214
Selective Corrosion of Phosphor-Bronze (*Illus.*)	214
Notes on New Books	216
"ENGINEERING" Patent Record (*Illus.*)	216

ENGINEERING

FRIDAY, AUGUST 29, 1947.

VOL. 164. No. 4257.

SPEED ON RAILWAY CURVES.

THE practice of maintaining the outer rail of a railway curve at a higher level than the inner rail was introduced at a very early stage in railway history. Legends to the effect that some engineers considered the inner rail should be the higher, because the inner wheels lifted when a vehicle overturned on a curve, are probably apocryphal, since abundant experience with stage coaches and colliery tramways must have made the problem a matter of plain commonsense, while the underlying simple mechanics was already well established. The principle involved is that the resultant of the centrifugal force and the weight of the vehicle must pass between the rails if the vehicle is not to overturn. If the resultant is normal to the centre of a line across the tops of the rails, the centrifugal force is balanced by the radial component of the weight across the canted rails, the wheel and spring loads on the two sides of the vehicle are equal, and the effects of speed, cant and radius may be regarded as in equilibrium.

Any such elementary analysis is modified, of course, by a number of practical considerations, predominant among which is the unavoidable variation in train speeds over curves of fixed cant and radius. The super-elevation of the outer rail must not, for example, be so great that there is any risk of a large light vehicle, such as an empty van, halted on the track, being blown over towards the centre of the curve by wind; nor of passengers being alarmed or subjected to discomfort by the list of a standing train. On the other hand, too little super-elevation unduly restricts the maximum permissible speed over a great length of track, including the curve itself, since the train would derail by flange-climbing of the outer wheels at a far lower speed than that theoretically necessary for overturning to occur. In this connection, it is important to bear in mind that the flange and friction forces which constrain the nominally rigid wheelbase of a railway vehicle to travel on a curved path are additional to those arising from centrifugal force, and exert a derailing tendency even if the cant is perfectly suited to the speed and curvature.

Even if the speed is safely low from the standpoint of derailment, however, but is higher than the equilibrium speed corresponding to the cant and radius, the unbalanced centrifugal effect tends to depress the outer rail more than the inner one, and to slue the track bodily outwards. To a less extent, similar effects take place in the opposite direction when speeds are below the equilibrium value, the tension in the drawgear being in the direction to enhance them. The general result, therefore, of speeds either above or below that ideally suited to the cant and radius is to increase the wear of rails and to enhance substantially the cost and labour of maintaining the track in correct alignment and level. This last is a most important consideration to the permanent-way engineer, who usually finds it uneconomical to attempt to maintain a super-elevation greater than one-tenth of the gauge. On main-line railways in this country, therefore, in all but very exceptional circumstances, the maximum cant is fixed at 6 in., irrespective of curve radius. Experience has shown that trains can travel safely and smoothly under conditions of cant deficiency, and that, within empirically fixed upper limits, speeds may be much higher than is theoretically appropriate to the super-elevation.

From the standpoints of wear and maintenance of material, a vehicle should avoid the shocks of sudden centrifugal forces in passing on to and off the tangents at the ends of a circular curve. Track laid out in such a manner is commonly shifted by high-speed trains so as to grade the change between straight and curve, and the wise permanent-way ganger does what he can to assist Nature by maintaining the alignment that demands the least amount of attention. The correct procedure, of course, is to provide in the original layout a transition between the straight and the circular curve, along which both curvature and cant increase gradually from zero to the full amount specified for the circular curve. Various factors combine to determine the desirable length and configuration of transition curves, but an imperfect transition is much better than none.

A point of importance in relation to the permissible speeds on railway curves is that the centrifugal forces are proportional directly to the square of the speed, but inversely to only the first power of the radius. Taken in conjunction with the fact that the British main-line railways are very restricted as regards lateral boundaries as well as by structural features of the permanent way, this factor calls for modifications of super-elevation and transitions rather than of radius in order to deal with the progressive increase of speed that has taken place since the general routes of the railways were first laid down. These problems were in abeyance during the war, but are now demanding renewed attention to anticipate future train speeds up to 20 miles per hour greater than those for which numerous existing curves were designed. Not the least difficulty, in many instances, is that the maximum practicable cant of 6 in. is already somewhat deficient on curves that, for topographical reasons, cannot be re-aligned to increased radii. Particular examination is needed, therefore, of all the conditions associated with deficiency of cant in order that overall running schedules may be hampered as little as possible by speed restrictions.

In the case of the London and North Eastern Railway, the whole subject has been thoroughly studied by a committee of engineers with the general object of evolving standards embracing not only super-elevation, but also the form and dimensions of transition curves and the design of high-speed junctions. To make their conclusions immediately applicable in practice, the committee have formulated a series of rules governing the speed of trains, on curves, in relation to radius, cant and length of transition; and these rules, together with explanatory matter, including a theoretical exposition of the principles involved and some sheets of graphical data, have been issued recently as Technical Booklet No. 11, by Mr. J. C. L. Train, the Chief Engineer.

On the whole, the rules do not embody any striking departures from established good practice in this country; but the fact that experience of their use during the past year or two has confirmed their soundness adds force to a number of points that are interesting, not only intrinsically, but also

for the opinions underlying them. The most desirable cant, for example, is based on economic considerations and is held to be that value which leads to even wear of components on each side of the track. It corresponds to a value of equilibrium speed derived by integrating the average weights and speeds of the various types of traffic passing over the curve, with the proviso that, wherever possible, it should be high enough to avoid speed restriction on the fastest passenger train. The assumptions underlying any such procedure are not beyond dispute, perhaps, but simplification is obviously warranted.

Regarding this last point, the committee recognise that different treatment should be given to primary, secondary and tertiary lines, for which the maximum speeds envisaged are 100, 70 and 50 m.p.h., respectively; but the differences are of quantity rather than of principle. Thus, the maximum allowable deficiency of cant (which, added to the actual cant on a curve, governs the maximum permissible speed) is a simple function of the actual cant for all classes of line, but is smaller for secondary than for primary lines, and smaller still for tertiary lines. The empirical rule adopted makes the deficiency decrease as the cant increases, for the reason that track imperfections have greater adverse influence on riding at the higher speeds associated with large values of cant. The formulæ, based on track observations, include allowance for drivers' errors and are considered to represent a satisfactory standard for the well-being of passengers and rolling stock, with an ample margin of safety. Exceptional circumstances can be envisaged in which strict adherence to the economic cant as well as the maximum-deficiency rule would entail a most undesirable speed restriction. The alternative of increasing the actual cant above the economic value may entail uneven wear of track, but this must be accepted as part of the price to be paid for high speed.

The cubic parabola, chosen by the committee as the plan form of transition curves, is firmly established in practice as giving a uniform rate of curvature increase and being simple to set out. As regards the more controversial question of the desirable length of transitions, the principles elaborated in Shortt's well-known paper* have been adapted to permit a limiting rate of change of unbalanced radial acceleration of 0·8 ft. per second per second in a second, which should lead to even smoother running than the value of 1·0 which Shortt considered satisfactory. The L.N.E.R. value corresponds to a limiting rate of change of 1·5 in. per second in either cant or deficiency, whichever is the greater, and leads to the simple rule that the length of the transition, in feet, is given by the product of maximum speed, in miles per hour, and cant or deficiency (whichever is the greater) in inches. The frequent cases where it is not possible to provide a transition curve long enough to suit the maximum speed for the circular part of the curve are catered for by the stipulation that the longest practicable transition should be used, and that a lower cant, or deficiency, or both, should be selected to give a lower maximum speed to suit the reduced length of transition.

Part of the booklet is concerned with curves having no transitions, which occur mostly in switch and crossing work. In the development of formulæ for permissible speeds through cross-over roads, double junctions and reverse curves, the distance of 43 ft. between the bogie centres of a typical coaching vehicle has been regarded as constituting a virtual transition, since the change from straight to circular-curved track is effected in that distance. Many engineers, no doubt, will question the worth of this argument since it can hardly apply to the locomotive, which, in respect of damage to track and liability to derailment, is usually considered to be the most critical component of a train. Apart from one or two rather confusing features and typographical inconsistencies, and an unexpected lack of reference to the "shift" needed to fit a transition between straight and circular curve, the booklet is admirably adapted for constant use and will be studied with keen interest.

* "A Practical Method for the Improvement of Existing Railway Curves." By W. H. Shortt. *Proc. Inst. C.E.*, vol. clxxvi, part II (1908-9).

POWER FROM THE WIND.

THE earliest traces of mankind which have been found in the form of bones, weapons and cave drawings, suggest that creatures kindred to the men of the present day existed some 30,000, possibly 40,000, years ago, but the historic events to which a date may reasonably be attached cannot be set further back than about 800 B.C. For the whole of the period of some 2,750 years since that time, except for about the last 130, mankind relied on muscular power, assisted by that furnished by wind and water, for all the mechanical operations in which he engaged. As the mechanical arts gradually developed, wind and water were pressed into service. The most extensive employment of the first of these agencies was probably in connection with ship propulsion and the sailing vessels which ultimately replaced the oar-propelled galleys of the early days held the seas unchallenged until 1802, when the Charlotte Dundas appeared on the Clyde.

Wind power was also extensively used for the operation of mills and pumping plants, a striking example of this latter application being furnished by the windmills of the Netherlands, which, quite literally, preserved the country from submergence. Water power was also employed for the driving of mills and other plants. Individual installations were, by modern standards, of small capacity, but their numbers are beyond computation. If ship propulsion is included, which it reasonably may be, it is probable that, in the pre-steam era, the total mechanical power furnished by the wind considerably exceeded that obtained from water-wheels. That situation has now been entirely reversed and while water power has become one of the major sources of energy almost throughout the world, wind power, even on the sea, has fallen to a position of little more than technical curiosity, except for purposes of recreation. Small plants of a few horse-power are still operated and still built, but their total power is insignificant.

In the period, representing only some 2 per cent. or less, of recorded history, in which mankind has turned over to fuel as his main source of power, he has utilised what from their nature must be limited supplies with gross extravagance, and as suggested in a leading article on page 109, *ante*, water-power resources may ultimately be found a dominating factor in the distribution of industrial activity throughout the world. Wind power was not mentioned in that article as a possible alternative source of energy for the future, but that a suggestion of that kind would not have been altogether too rash is indicated by a passage in a recent report on wind power published by the Federal Power Commission of the United States. It states that "the occasion for investigation of the possibilities of utilising the wind as a source of electric energy arises in part from the fact that a large number of the best sites for the generation of hydro-electric energy . . . have already been developed . . . Large sections of the country are not only relatively deficient in hydro possibilities, but also not particularly favoured in the availability of fuel for steam generation. They do, however, have relatively constant winds of unusually high average velocities."

It will not be supposed that this report, entitled *Electric Power from the Wind*, and compiled by Mr. Percy H. Thomas, is a document on the strength of which large wind-power installations may be put in hand at once. It does, however, represent a careful investigation of an interesting problem and may ultimately come to constitute an early stage in the restoration of wind power to a position a little nearer to the predominance which it once occupied. The practical inconveniences attaching to the utilisation of wind power, arising both from the intermittency and unreliability of the source of energy and from the large size of the plant in terms of output, have almost restricted its use to small units, and to duties for which continuous service is not essential, but there is one relatively large plant in operation. This is a 1,000-kW wind-power electric generator situated at the top of a 2,000-ft. mountain, known as Grandpa's Knob, near Rutland in the State of Vermont, and connected to the mains of the Central Vermont Public Service Corporation. An illustrated description of this interesting installation appeared in our columns some five years ago.*

There are numberless small-capacity wind-power electric generators in service, usually operating in connection with storage batteries, but the Grandpa's Knob machine differs from them not only in its much greater capacity, but in this important fact that it is connected into a general supply system. The main part of the energy supplied by the Central Vermont Corporation is obtained from hydro-electric plants and the wind-power generator can only contribute to the supply when the wind is favourable. In this intermittent service, however, it does not differ fundamentally from the water-power plants. Many systems incorporate hydro-electric installations which cannot operate continuously; in some cases, climatic conditions in different districts enable some of the water-power stations of a large system to furnish current when others are perforce shut down and the provision of stand-by steam stations, operating when water supplies fail, is quite usual.

It might appear that the performance of a wind-power station is likely to be more erratic than that of one depending on stream or river flow, but that would not prevent it from furnishing useful supplies; if a system of wind stations were spread over a large area, the effects of intermittency would be to a considerable extent evened out. Actually, however, the reports suggest that wind stations are likely to be less erratic in output than water stations, not more so. From an analysis of wind conditions over large areas in the United States, the conclusion is drawn that "both in degree of variation and the length of periods of deficiency, wind power probably has a marked advantage over water power, which may be affected both by dry seasons and dry years."

This encouraging pronouncement does not, in itself, constitute a complete case for the development of wind-power plants of large capacity; questions of cost, both of construction and operation, have important bearing. They are, however, answered satisfactorily in the report, in which the opinion is expressed that the "construction cost [would be] as low as any; in the opinion of the author, ultimately lower than any other." The operating costs would be "very low." The whole matter has been worked out in great detail and designs for both 7,500-kW and 6,500-kW units have been prepared. It is considered that a proper investigation of the commercial possibilities of wind-power generation on a large scale would require the construction of a plant or plants of a capacity of the order of 7,000 kW, the 1,000-kW Grandpa's Knob unit being too small to furnish the necessary information. The difference between the 7,500-kW and the 6,500-kW units which have been designed is that the former is adapted for a maximum rated wind of 34 m.p.h. and the latter for one of 28 m.p.h. Both are twin-wheel machines, the reason for adopting this arrangement being that, as it was considered desirable to place the generating machine on the top of the tower on which the wheels are carried, in order to obtain a direct drive, the adoption of two wheels mounted at the ends of a cantilever on a turntable provided ample room for the electric generator between them.

As power is to be delivered to an alternating-current system it is necessary that the generating unit should run at a constant speed. This condition is met in the Grandpa's Knob unit by employing feathering blades, but in the proposed designs the wheels would run at variable speed and drive a direct-current generator coupled to a synchronous converter which would run in synchronism with the circuit being supplied. The towers carrying the wheels would be about 500 ft. high, as the difference in energy content of the wind at this height has been found to be as much as three times that at ground level. Clearly, before any extensive installation is carried out, it would be necessary to build and test one or more units of the suggested design. That progress in this field of wind-power generation is likely to be made is indicated by the statement that "at least two permanent installations for the normal supply of utility power are reported to be contemplated."

* ENGINEERING, vol. 154, page 81 (1942).

NOTES.

INDUSTRY'S COST OF LIVING INDEX.

WITHIN the past few days, the Ministry of Labour have issued the first of their comparative figures of retail prices, which replace the former (and generally discredited) cost-of-living index. Under the new system, the level of retail prices on June 17, 1947, is taken as 100; and, by comparison, the figure on July 15 is calculated to be 101. Two days before those figures were published, however—that is, on Monday last, August 25—the National Coal Board made an announcement which will certainly cause a much greater rise and will have unfortunate repercussions throughout the whole of British industry; namely, that the price of coal at the pithead would be raised by 4*s.* per ton on September 1. As it had been stated previously that railway freight rates are to be increased some 24 per cent. on October 1, a further rise in the price of coal will result from that. The reasons given by the National Coal Board for the immediate increase amount, simply, to an admission that the coal-mining industry is not paying its way; that is to be understood, but the analysis, also published, is illuminating. Of the extra 4*s.*, the introduction of the five-day week accounts, it is stated, for "substantially more" than 2*s.* 6*d.* per ton, by its effect on the wages bill—and there is still no assurance that even the modest target of 200 million tons of coal a year will be achieved. By comparison, the other items listed seem almost trivial though several of them would have been regarded, in pre-war days, as justifying considerable discussion. Various benefits to the miners, such as paid holidays, the removal of charges for the use of pithead baths, etc., add 7*d.* per ton; staff superannuation and other staff items, 4*d.* per ton; compensation for redundant staff, national insurance contributions, and the loss of railway freight rebates add 3*d.* on each ton, and another 1*d.* per ton is the cost of new staff. Increased costs of materials—timber, etc.—account for 4*d.* per ton, which is just twice as much as the addition attributed to research, recruitment, education and training. Another 6*d.* per ton represents losses incurred in selling imported American and Polish coal at the current British prices; so, apparently, the accounts are still unbalanced. The effect of these increases upon iron and steel, gas, electricity, and rail and sea transport, remains to be seen. It is bound to be considerable, and to render more difficult than ever the task of expanding the volume of exports sufficiently to afford any real relief to the national finances.

THE WORK OF THE MINISTRY OF SUPPLY.

The responsibilities of the Ministry of Supply in their newly-acquired fields of heavy electrical plant, coal-mining machinery, and railway coal-to-oil conversion, are briefly to assist manufacturers to obtain all the necessary materials, components and labour, the latter through the Ministry of Labour; to render help over any production difficulties which may arise; and to plan and supervise overall production so that deliveries to the users are made in accordance with an agreed programme. In the case of heavy electrical plant for power stations in the British Isles, the Central Electricity Board, the North of Scotland Hydro-Electric Board and the Ministry of Commerce for Northern Ireland prepare programmes of the new equipment required and of the repair work to be done to meet the increasing demand for electricity. Orders are then placed with manufacturers by the electricity undertakings, but liaison with the electricity authorities and the manufacturers, on matters of major policy, is maintained through the medium of the Heavy Electrical Plant Committee sitting under the chairmanship of the Minister of Supply. In the matter of coal-mining machinery, the relationship between the Ministry of Supply and the National Coal Board is similar to that existing between the Ministry and the Central Electricity Board and the other two bodies mentioned above. The Coal Board furnishes the Ministry with a programme of overall requirements, and the necessary individual orders are placed by the Coal Board's Area Supplies officers, but a production programme is drawn up by the Ministry of Supply. In the case of conversions from coal to oil burning on the railways, the Ministry places contracts for the supply of equipment required by the railways for the conversion of locomotives and for the oil-storage installations. The erection and fitting of the equipment is carried out by the railway companies but the Ministry of Transport is the co-ordinating planning department for all questions concerned with coal-to-oil conversion on the railways. In these matters, the Ministry of Supply is in close contact with the Railway Executive Committee and the Ministry of Transport.

ATOMIC PILE IN GREAT BRITAIN.

The first atomic pile in this country was put into operation at the Atomic Energy Research Establishment at Harwell, Didcot, Berkshire, recently. The pile, which is known as the Gleep (graphite low-energy experimental pile) is the first major unit to be completed at Harwell and it has been built primarily for experimental work in nuclear physics. Until a more powerful pile is placed in service in 1948, however, the Gleep will be used during the interval for the production of small quantities of radio-active isotopes for biological and medical research. These radio-active materials are required, in the first place, for the work of the Medical Research Council, but their use is likely to extend in science generally and also in industry. The pile has been designed largely by a group of New Zealand scientists working at Harwell. Many scientists of the United Kingdom, however, have contributed to the production of the pure graphite and uranium required and have designed and made the instruments needed for the pile. Considerable assistance has also been obtained from Canada, particularly in the testing of the graphite. The engineering and constructional work on the pile has been carried out by the Ministry of Works and their contractors, Messrs. W. E. Chivers and Sons, Limited, 171, Plaistow-road, London, E.15, and Messrs. Matthew, Hall and Company, Limited, 26, Dorset-square, London, N.W.1. The pile was constructed in the comparatively short time of fifteen months from commencing work on the site.

DISPOSAL OF AMERICAN STANDARD SHIPS.

Some particulars of the disposal of standard ships built during the war were given in the report of Mr. J. Lewis Luckenbach, president of the American Bureau of Shipping, presented on July 29 at the semi-annual meeting of the Board of Managers. At June 30, Mr. Luckenbach stated, the number of vessels laid up in the Maritime Commission Reserve Fleet was 1,204, totalling about 6,000,000 tons gross. This compares with a peak figure of 1,733, on October 31, 1946, the reduction being due to the demand for charter tonnage and the sale of many vessels to foreign Governments and to private owners. Of the vessels still laid up, 506 were Liberty ships—a considerable fall from the figure of 851, on January 1; 83 were Victory ships; and 217 were tankers, of which 42, built before the war, would probably be scrapped. Vessels, built during the war, which had been sold by the Maritime Commission, totalled 1,032 at May 31, 1947, and had an aggregate tonnage of 7,194,192; they included 109 tankers, 542 standard Liberty cargo ships, 87 Victory ships and 261 standard cargo ships of the C types. All of these vessels had been handed over to their new owners at that date. United States interests bought 275 of them, representing 28 per cent. of the total tonnage sold, and the rest were distributed under 25 foreign flags. Of these remaining ships, Britain was the most considerable purchaser, taking 161. Greece came next, with 100; 81 were transferred to the flag of Panama; 74 to France, 68 to Italy, 67 to the Netherlands, and 66 to Norway. South American countries took a total of 72. It was noteworthy, said Mr. Luckenbach, that, of the 46 Diesel-driven cargo ships of the C1-A type which were built, 37 were sold to foreign owners, but only three to American owners; of the Victory ships sold, American interests bought only 6; and that, of the 36 coal-burning ships of the N3-S-A1 type, 30 were bought by Britain. Turning to consider the state of the United States mercantile marine, Mr. Luckenbach pointed out that the total of privately-owned vessels, exclusive of those on the Great Lakes, did not compare very well with the pre-war position, being only 800, of about 6,000,000 tons gross, as against 1,252, of 7,111,383 tons gross, at January 1, 1939; though, he added, the average speed was higher, being 14 to 15 knots, as against 12 knots. About 300 of the present ships were tankers, averaging about 10 years old, 13½ knots in speed, and about 14,700 tons deadweight. He emphasised particularly the unsatisfactory state of the United States merchant fleet in respect of intermediate ships, carrying both passengers and cargo, the numbers of which had declined from 152 of 1,104,562 tons gross, in 1939, to 45, of 350,000 tons, in 1947. "The American passenger-ship fleet," he said, "is to-day at its lowest ebb since the end of World War One," though "American shipping interests are now operating the largest individual fleets of cargo ships they ever assembled for peace-time business. As foreign competition develops in the next few years with new vessels, many of the American chartered ships will be placed in the laid-up reserve fleets, despite the absence of the huge pre-war German, Italian and Japanese fleets, because of our higher operating costs and the reduction in volume from the current abnormally high traffic. . . . The United States emerged from the war with a tremendous deficit in all classes of passenger-carrying vessels and our merchant marine was sadly unbalanced by a lack in liner tonnage, but an overabundance of all other types of vessels. . . . There are but two mitigating factors: the slowness with which foreign shipbuilding has proceeded, due to shortages of material and labour, and the appointment of the President's Advisory Committee for the review of the entire merchant marine problem."

THE NEWCOMEN SOCIETY.

The programme of papers to be presented during the 1947-48 session of the Newcomen Society for the Study of the History of Engineering and Technology, is, as usual, as notable for its variety as for its authority. At the first meeting of the session, on October 15, Mr. P. C. Dewhurst, M.I.C.E., will deliver a paper, "Norris Locomotives in England, 1838-42," containing what may be termed the "English end" of his extensive researches into the locomotives, and their employment, built by the American firm of Norris, of Philadelphia. On November 12, a joint meeting will be held with the Chartered Institute of Patent Agents, to hear a paper on "The Early History of Patents for Invention," by Mr. M. Frumkin. Two papers are to be presented on December 10, these being "La Mission de Gabriel Jars dans les Mines et les Usines Britanniques en 1764," by Mr. Jean Chevalier, and "The Malham Moor Mines, Yorkshire, 1790-1830," by Dr. A. Raistrick, M.Sc., F.G.S., the latter being a continuation of a paper by Dr. Raistrick in the preceding session. At the meeting on January 14, Mr. Paul Grodzinski, A.M.I.Mech.E., will speak on "Sir John Barton's Iris Ornaments"; and on February 11, a paper on "Trevithick and the Merthyr Tramroad," will be read by Mr. S. Mercer, A.M.I.C.E. The subject for March 10 is "Distillation," to be introduced by Professor R. J. Forbes, of Amsterdam. The concluding meeting of the session will be held on April 14, when there will be two papers, the first being on "Warehouse Hoists," by Mr. T. M. Hoskison, M.A. The second, on "Brake Wheels and Wallowers"—terms which should need no explanation to students of the millwright's craft—will be presented by Mr. Rex Wailes, and is based on some notes found among the papers of the late Mr. H. O. Clark, of Norwich, whose remarkable model of the Sprowston post-mill (now in the Science Museum) was described and illustrated on page 157 of our 159th volume (1945). The dates of the 1948 summer meeting of the Society are provisionally arranged to be June 3-5. All the dates given for the winter meetings are Wednesdays, and the times and places will be announced in due course in our "Notices of Meetings" column. The address of the Society is that of the assistant secretary, Miss G. Bingham, O.B.E., 43, King's-road, Chelsea, London, S.W.3.

BANK TUBE STATION.—At the London Passenger Transport Board's Bank station on the Central Line of the Underground, a third escalator, 103 ft. in length, and 51½ ft. in depth, was opened on August 25. The three pre-war escalators were destroyed by a bomb in 1941.

BABBITT ALLOYS FOR PLAIN BEARINGS.

By P. G. Forrester, M.Sc.

(*Continued from page* 185.)

Babbitts may conveniently be divided into three groups: high-tin alloys (substantially lead-free), intermediate alloys and high-lead alloys. These three groups have the characteristic structure of hard compounds in a soft matrix; they contain the same or similar types of compounds, and it is in the composition and properties of the matrix phase that they differ.

High-Tin Alloys.—The high-tin Babbitts in common use are all based upon the tin-antimony-copper system, the structural divisions of which (for high tin content) are shown in Fig. 1.* The compositions normally employed for bearings fall within the areas A and B. Those in area A consist of the pseudo-eutectic matrix with needles or stars of Cu_6Sn_5, while those in area B have the same constituents with the addition of cubes of SbSn. The hardness and tensile and compressive strength of these alloys have been tested by a number of complete series of engine or mock-engine tests been made and published on alloys of different compositions. At present the relative resistance to cracking of tin-base alloys can only be compared on the basis of general experience. This indicates that maximum resistance to cracking is obtained with fairly low percentages of antimony and copper, such as, 3 to 7 per cent. antimony, and 2 to 4 per cent. copper. It is also believed that massive and rigid bearings, such as the connecting-rod bearings of Diesel engines, can tolerate a higher proportion of antimony and copper than bearings of relatively light construction, such as the connecting-rod bearings of carburettor engines for automobiles or aircraft. The less highly-alloyed bearings are, of course, less resistant to spreading, and a compromise between crack-resistance and resistance to spreading is sometimes necessary.

The hardness, tensile and compressive strength and fatigue strength of these alloys are all reduced to a considerable extent by increase of temperature. The percentage reduction in strength for a given rise in temperature varies little with antimony and copper content.

Effect of Other Elements on Tin-Antimony-Copper Bearing Alloys.—The presence of lead results in based upon the lead-antimony-tin system and, like the tin-base, have a structure consisting of hard crystals in a relatively soft matrix. The nature of the hard crystals and of the matrix depends upon the tin content, and most of the alloys in commercial use fall into one of two classes. First, those containing 12 to 18 per cent. of antimony and up to 5 per cent. of tin, in which the primary crystals consist of an antimony-rich solid solution and the matrix consists mainly of a ternary eutectic of phases approximating to lead, antimony and SbSn, respectively. Secondly, those containing about the same amount of antimony (12 to 18 per cent.), but with 10 to 12 per cent. of tin; in these alloys the primary phase is SbSn, which takes the form of cubes, as in the high-tin alloys, while the matrix consists mainly of a pseudo-binary eutectic of lead and SbSn.

The second class of alloy, that with the higher tin content, has generally better properties than the first, having greater compressive strength, fatigue strength and ductility. The solidus temperature of both classes is about 240 deg. C. All the lead-base alloys are prone to segregation as both the antimony-rich and the SbSn primary crystals are less dense than the high-lead matrix, and so tend to

Fig. 1.

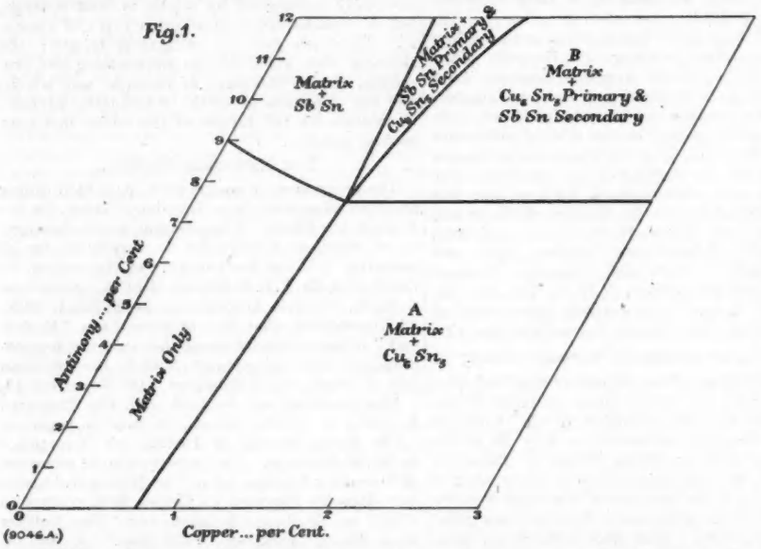
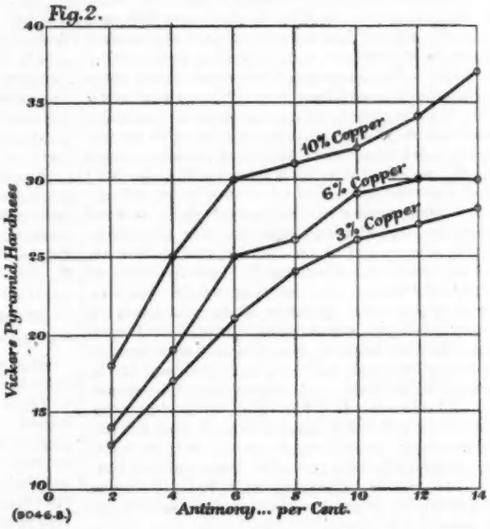

Matrix + Sb Sn
Matrix + Sb Sn Primary + Cu6 Sn5 Secondary
B Matrix + Cu6 Sn5 Primary & Sb Sn Secondary
A Matrix + Cu6 Sn5
Matrix Only
Antimony ... per Cent.
Copper ... per Cent.
(9046.A)

Fig. 2.



investigators; the numerical results obtained show apparent discrepancies, probably due to the use of different casting and testing conditions, but there is fairly general agreement as to the manner in which composition affects these properties. As copper or antimony content is increased, the hardness and tensile strength rise while ductility falls. The hardness figure gives a fairly reliable indication of the other static strength properties and hence indicates the relative liability of the alloys to flow under load. In Fig. 2 the relationship between hardness and antimony content is shown for alloys of different copper contents. These values were obtained on sections cut from ½-in. diameter cylindrical chill-castings, using a Vickers pyramid hardness tester with a 10-kg. load.

The fatigue strength of tin-antimony-copper alloys, as determined by Wöhler tests or by Schenk alternating-bend tests, increases with increasing antimony and copper, though the increment obtained by a given percentage addition falls off as the proportion of alloying element increases. The resistance of an alloy to cracking in service, however, does not appear to be directly related to fatigue strength as determined by standard methods. Machines have been used which subject bearing metals to repeated-impact loading, and these have been reported to give results more analogous to those of practical experience. At present, however, there is no laboratory test that can be claimed with confidence to give an accurate index of an alloy's resistance to cracking in service, neither has any

* W. T. Pell-Walpole, *Jl. Inst. Met.*, vol. 68, page 217 (1942).

the formation of a peritectic complex with a melting-point of about 185 deg. C., *i.e.*, about 40 deg. C. lower than that of the rest of the alloy. This results in some strength reduction at elevated temperatures, and may also lead to "wiping" under heavy loading. Other effects arising from the presence of lead are the formation of minute shrinkage cavities* a coarsening of the Cu_6Sn_5 needles and a reduction in bond strength. For these reasons, specifications for high-tin alloys usually restrict the lead content to 0·5 per cent., or in some cases 0·35 per cent. There are, however, numerous cases of alloys of higher lead content giving satisfactory service, and it is probably only in exacting applications that severe restriction of lead content is necessary.

Cadmium increases the hardness, tensile strength and fatigue strength of tin-base alloys. This strengthening effect reduces to some extent liability to failure by spreading or by cracking. If cadmium is present, the percentage of lead must be restricted to about 0·25 per ceht., for otherwise a ternary eutectic melting at 150 deg. C. is formed. Nickel must also be restricted to 0·2 per cent. when cadmium is present.

Nickel is sometimes added, with the object of increasing resistance to cracking; so far as the author is aware no figures of mechanical properties or bearing performance of nickel-containing alloys have been put forward. Zinc, aluminium and bismuth are all regarded as detrimental.

Lead-Base Babbitts.—The lead-base Babbitts are

* W. A. Cowan, *Jl. Inst. Met.*, vol. 39, pages 53-60 (1928).

rise. The extent of segregation is usually restricted by the addition of copper, in quantities varying between 0·5 and 2 per cent. Copper has some hardening effect on the alloys, and causes a sharp increase in the liquidus temperature. Arsenic has been recommended as an addition to low-tin alloys, and is said to reduce segregation and to increase hardness, and especially the extent to which hardness is retained at elevated temperatures. On the other hand, arsenic has been reported to impair impact resistance and adhesion. Advantages have also been claimed for the addition of nickel and of silver. The value of cadmium, also sometimes added, is doubtful.

Lead-base Babbitts are generally regarded as a cheaper substitute for tin-base, and it is only very rarely that claims of outright superiority for specific lead-base alloys have been made (*e.g.*, Willi).* Most lead-base alloys lose hardness at elevated temperatures to a greater extent than do tin-base, and their inferiority has been attributed to this property. Some research has, therefore, been devoted to finding lead-base alloys showing less hardness loss at elevated temperatures, and two alloys have been suggested,† which are, it is claimed, the equal of tin-base in this respect. It is likely, however, that other factors besides loss of hardness are involved. One such factor is probably

* A. B. Willi, *Mech. World*, vol. 112, pages 338-341, 365-367 (1942).

† A. J. Phillips, A. A. Smith and P. A. Beck, *Proc. A.S.T.M.*, vol. 41, pages 886-893 (1941): and H. W. Gillett and R. W. Dayton, *Metals and Alloys*, vol. 15 pages 584-587 (1942).

the lower thermal conductivity of the lead alloys, which reduces the rate at which heat can be dissipated from the bearing surface. It also appears that tin-base retains a boundary lubricant film longer than lead, for the former continues to run longer after lubrication failure. Lead-base alloys are rather more difficult to line into bearings owing to their greater tendency to drossing and to segregation, and more care is required to get a satisfactory bond. Properly lined, however, they function satisfactorily under moderate conditions of load and speed.

Tin-Lead-Base or Intermediate Alloys.—So far, we have considered the tin-base alloys substantially free from lead, and the lead-base alloys containing up to about 12 per cent. of tin; in the latter alloys the tin is combined with antimony as SbSn and is practically absent from the matrix. Intermediate between these two classes is a whole range of alloys which contain both tin and lead in the matrix. Examples of such alloys, taken from A.S.T.M. and D.I.N. (1931) specifications are given in Table I.

TABLE I.—*Typical Intermediate Alloys.*

Alloy.	Sn.	Pb.	Sb.	Cu.
A.S.T.M. No. 6	20	63·5	15	1·5
W.M. 20	20	64	14	2
W.M. 42	42	41	14	3
W.M. 50	50	33	14	3
A.S.T.M. No. 5	65	18	15	2
W.M. 70	70	12	13	5
A.S.T.M. No. 4	75	10	12	3

The most comprehensive investigation of the mechanical properties of these alloys is that carried out by Göler and Scheuer,* and this is substantially in agreement with the work of other investigators. At room temperature the mechanical properties of the intermediate alloys are not greatly different from those of the high-tin and high-lead alloys. There is a gradual rise in hardness and tensile strength as the amount of tin is increased. The resistance to compression, to impact-compression and to fatigue is rather lower for the alloys containing 20 per cent. to 50 per cent. of tin than for the high-lead and high-tin alloys. At elevated temperatures the intermediate alloys are inferior as regards mechanical properties to both the high-tin and the high-lead alloys.

It is largely on account of this high-temperature weakness that much criticism has been levelled against the intermediate alloys, especially in times of tin scarcity. It has been claimed that they are generally inferior to the high-lead alloys and that in view of their greater tin content and higher cost there is no justification for their use. In 1936, the German D.I.N. specifications omitted all alloys containing between 20 per cent. and 80 per cent. of tin. In 1942, the British Ministry of Supply made a similar recommendation that the use of alloys between 12 per cent. and 68 per cent. of tin should be discontinued.† It is very probable that these steps were justified from a tin economy point of view, and that the intermediate alloys represent a less profitable use of tin than the high-tin and high-lead (10 per cent. tin) type of alloy. There can be little doubt, however, that to claim that the intermediate alloys can never show superior bearing properties to the high-lead is to place too much reliance on the results of tests of individual mechanical properties. Alloys with between 20 per cent. and 80 per cent. of tin have given satisfactory service in rolling mills, electric motors, crankshaft bearings and many other applications, and many cases have been cited in which the substitution of a high-lead alloy has resulted in early failure. It seems that these alloys have advantages over the high-lead alloys which are not reflected in the ordinary mechanical properties. One such advantage may lie in a superior resistance to wear. The intermediate alloys have an unquestioned advantage over the high-lead alloys in their greater ease of casting. They are much less prone to segregation and their properties are less dependent upon the exact casting conditions, a major consideration where bearings have to be re-metalled under difficult conditions and where limited facilities are available.

Design Factors in the Performance of Babbitt Bearings.—It has been shown earlier that the chief limitation to the use of Babbitt bearings is failure by cracking or, less frequently, by spreading. The load conditions which can be withstood without either type of failure depend not only on the white metal itself, but also upon the design and manufacture of the bearing assembly and, by attention to the latter factor, the range of permissible load conditions can often be considerably increased. The first aim of the design and manufacturing method is to obtain a bearing which is efficient from a hydrodynamic point of view and which, therefore, runs as cool as possible and gives minimum frictional stress on the bearing surface. In particular, the ratio of length to diameter should be appropriate to the particular application, clearance should be correct (about 0·0005 in. to 0·001 in. per inch of diameter is generally regarded as satisfactory for Babbitt bearings), and oil grooves must avoid the area of maximum pressure.

The second major aim in designing and manufacturing a bearing is to obtain effective support of the white metal by the backing material. The backing material is required to support the Babbitt lining in two different ways: it must prevent flexure of the lining under fluctuating load, for such flexure results in fatigue failure; it must also give lateral support by taking its share of the tensile and compressive stresses imposed on the lining. To fulfil these requirements the backing itself must be strong and the bond to the white metal must be good. When a fairly light bearing shell is used, adequate strength is obtained only when this shell is firmly mounted into the connecting-rod or other part. This factor is of particular importance when thin strip-lined shells are used. Great importance is attributed to getting the correct "nip," or interference fit, with such bearings and it has been stated that movement of the bearing in its housing is the greatest single cause of failure.* Thus, so far as the prevention of flexure is concerned, the directly lined bearing is to be preferred.

Of equal importance to a backing of adequate strength is a sound strong bond to the white metal. In thin linings especially, the bond is subjected to stresses of the same order as those in the white metal itself. If bond failure occurs under these stresses, the effective strength of the lining is reduced and heat conduction is impaired, making eventual breakdown probable. Good adhesion is largely a question of lining technique (discussed later) but the design of the bearing is also a factor. A good bond is most readily obtained on a semi-circular shell of uniform thickness and with no discontinuities. If a shell or "brass" is thicker at some parts than at others, cooling is slower at those parts and there is a tendency for porosity and contraction cavities at the bond and in the white metal. From this point of view it is clear that a bearing with lined shell inserts is generally preferable to a directly lined bearing, though the latter is better from the point of view of preventing flexure; so that while the directly lined bearing is to be preferred when it can be designed so as to have few discontinuities on its back, if major changes of section are inevitable the half-shell bearing is probably better. The use of "dovetails" in directly-lined bearings is definitely undesirable, for they almost inevitably cause bad adhesion on account of unequal cooling. With good lining technique, such dovetails are quite unnecessary.

It has been noted that one function of the backing is to provide lateral support of the lining, thereby increasing its effective strength. This increase in effective strength is much greater for thin linings than for thick, for the strengthening effect of the basis material decreases as the distance from its surface increases. It is, in fact, always possible to avert fatigue failure of a Babbitt bearing by using a sufficiently thin lining. With very thin linings, however, conformability is reduced, so that more accurate assembly is necessary than when thicker linings are used. Another practical disadvantage of thin linings is that if failure should occur, the resulting knock may be insufficient to indicate failure before damage to the shaft has occurred.

These disadvantages are reduced, to some extent, by the use of an alloy of intermediate properties, such as copper-lead, between the steel and the white metal. This provides an emergency running surface and slightly greater embeddability. Such trimetal or "sandwich" bearings are expensive, but have very useful properties. Another type of bearing which combines to some extent, the good bearing properties of a Babbitt with the strength of a copper-base alloy is the "Durex 100" bearing described by Lignian.* A porous copper-nickel alloy is bonded to steel strip, after which lead-base Babbitt is applied (*in vacuo*), so as to fill the pores in the copper-nickel. A 0·003 in. overlay of Babbitt is left after machining.

The present attitude to lining thickness may be summarised as follows: there is generally little to be gained by having a thickness much greater than about 0·10 in., though linings of this and greater thicknesses are used under conditions where a good deal of wear must be allowed for or where it is necessary to have considerable warning of failure. Automobile practice favours a thickness of 0·010 in. to 0·020 in., which provides fairly good fatigue resistance combined with good embeddability and conformability. Where a bearing of greater fatigue resistance is required, and precision machining and assembly are possible, thicknesses of 0·005 in. or less are quite practicable. Such bearings are superior to copper-lead in most respects, though inferior to thicker Babbitt linings as regards embeddability and conformability.

(To be continued.)

THE "MODEL ENGINEER" EXHIBITION.

THE 22nd *Model Engineer* Exhibition, organised by Messrs. Percival Marshall and Company, Limited, the publishers of the well-known journal of that name, was opened on August 20 at the New Royal Horticultural Hall, Westminster, S.W.1. It closes to-morrow, August 30, at 9 p.m., by which time, it is safe to assume, the attendance figures should bear comparison with those of any previous year. While a first impression may be that the models are not quite so numerous as those of last year, there is certainly no falling-off in the quality of workmanship; but the probability is that the seeming diminution in numbers is more apparent than real, and is due to a difference in the layout of the exhibition. This year there is no passenger-carrying railway down the hall, flanked by rows of locomotives of greatly varying types and ages and operated on occasion by veritable main-line drivers; nor is the workshop of the Society of Model and Experimental Engineers in its usual place. Instead, there is a circular arena, some 50 ft. in diameter, containing a board track and an annular water tank, in which self-propelled model cars, aircraft and motor boats career round a central pole at speeds which, not so many years ago, would have been regarded as highly creditable in their full-sized prototypes. The innovation is undoubtedly popular, though there will be many, we believe, to find satisfaction in the hint, given in the catalogue, that the railway track may be restored in some, at least, of the future exhibitions.

Doubts have been expressed that the ranks of amateur model engineers may not receive sufficient recruits to compensate for inevitable wastage. The Services, which were well represented, are certainly doing good work to counteract any such tendency; but there is some reason to fear that there may be a falling-off in the numbers of young model makers who apply themselves to the construction of models requiring the use of lathes and other metal-working tools, the prices of which have soared to heights beyond the scope of many purses. A general survey suggests, too, that the finish of some of the small hand tools does not compare too well with the standards of pre-war days. Otherwise, there is ample evidence that model engineering retains all its wonted vitality and breadth of appeal. Mr. Percival Marshall, in his introduction to the catalogue, adduces an impressive array of arguments to justify the pursuit, but they are unnecessary; model makers of all ages (and both sexes) will continue to make models for the best of all reasons—they enjoy doing it, and seeing it well done.

* K. von Göler and F. Scheuer, *Z. Metallk.*, vol. 28, pages 121-126, 176-178 (1936).

† "Economy in Tin in Plain Bearings and Bearing Metals," Ministry of Supply Ref. P.B.1, 1942.

* W. B. D. Brown, P. T. Holligan and J. W. Warrington, *Aut. Eng.* vol. 31 (408), pages 83-88 (1941).

* J. A. Lignian, *Product. Eng.*, vol. 17, page 335 (1946).

LETTER TO THE EDITOR.

EFFECT OF CENTRIFUGAL FORCE IN AXIAL-FLOW TURBINES.

To the Editor of Engineering.

Sir,—In your issue for August 15, on page 160, Mr. Pochobradsky re-asserts that radial equilibrium is inconsistent with the usual conception of free-vortex flow, and that only constant specific-mass flow is theoretically possible between two co-axial cylindrical surfaces.

The crux of the matter appears to be that the aero gas-turbine engineer states that there is radial equilibrium before and after any row of turbine blades and Mr. Pochobradsky makes the additional hypothesis that there shall be no radial redistribution of mass while the gas passes through the blades.

Since it is established that radial redistribution can, and does in fact, take place while the gas passes through a row of turbine blades, to result in radial equilibrium after the blades, the only conclusion is that Mr. Pochobradsky's conception of free-vortex flow is different from that usually accepted.

Yours faithfully,

J. H. C. Atkins, M.A., A.M.I.Mech.E.

199, Beechwood-avenue,
Coventry.
August 11, 1947.

OBITUARY.

MR. WALTER POLLOCK.

The exhibition organised by the Shipwrights Company and held in London in January of this year was generally recognised to owe much to the vigour and enthusiasm of Mr. Walter Pollock, who was chairman of the committee responsible for it. That his death should have followed so soon afterwards as August 22 will be the more regretted, therefore, by those who watched and shared that enthusiasm, which seemed to be almost unaffected by his failing health though it may, perhaps, have contributed to it.

Walter Pollock was born on March 24, 1873, and was a son of James Pollock, who, two years later, founded the shipbuilding firm of James Pollock, Sons and Company, Limited, of London and Faversham. After leaving the City of London College in 1889, he served a five years' apprenticeship under his father and then went to the Clyde for a short time to extend his experience of marine engineering. In 1895, he went into the London office of Mr. Joseph Constant, then well known as a naval architect and consulting marine engineer, specialising in tugs, ferry boats and similar small craft, remaining with him for eight years. He then rejoined his father's firm and, in 1910, shortly before Mr. James Pollock's death, was appointed chairman, a position which he occupied for the rest of his life. An important step in the fortunes of the firm, and in the propulsion of small craft, was initiated by Mr. Walter Pollock in 1910, when he undertook the representation in this country of the Bolinder heavy-oil engine; and another notable advance was in 1917, when, at the instigation of Lord Fisher, then First Sea Lord, he established the shipyard at Faversham, originally for the construction of the "X" lighters designed for the Gallipoli operations.

Mr. Pollock was a member of the Institution of Naval Architects, the Institution of Mechanical Engineers and the Institute of Marine Engineers, and was the author of a number of papers dealing with the construction and propulsion of the tugs, coasters, and other small vessels in the design of which he had specialised. He had also written several books on these subjects, the most recent being *Small Vessels*, which was reviewed on page 477 of our 162nd volume (1946). An earlier book which he wrote, *Hot-Bulb Oil Engines and Suitable Vessels*, published in 1919, was one of the first to deal specifically with his particular field. He was a member of the Court of Assistants of the Worshipful Company of Shipwrights and was also a past Master of the Plaisterers' Company.

MR. ROY CHADWICK.

Engineers and scientists in all parts of the world will have received with regret the news of the death of Mr. Roy Chadwick, who was one of the four victims of the crash of the prototype Avro Tudor II air liner when on a test flight on August 23. The three other persons to lose their lives were Mr. S. A. Thorn, chief test pilot of Messrs. A. V. Roe and Company, Limited, Mr. D. J. B. Wilson, of the firm's test flight section, and Mr. J. Webster, the radio operator. The accident, it will be recalled, occurred soon after the aircraft took off from Messrs. A. V. Roe's test airfield at Woodford, Cheshire. Mr. Chadwick, who was 54 years of age, was technical director of Messrs. A. V. Roe and Company, having been appointed to that position early this year after acting for many years as chief designer. Mr. Chadwick was born at Farnworth, Lancashire, and, in 1910, at the early age of 17, joined the staff of Messrs. A. V. Roe and Company, then established at Ancoats, a suburb of Manchester. When still quite a young man he was appointed the firm's chief designer. The machine which first brought him into national prominence was the Avro 504 training aircraft of the 1914-18 war. During his long tenure of the office of chief designer, he was actively concerned with the design and production of upwards of 30 types of Avro aeroplanes. His first machines in the 1939-1945 war were the Anson reconnaissance aircraft and the Manchester twin-engined bombing aeroplane. The large four-engined Lancaster bomber which saw such great service during the recent war was probably Mr. Chadwick's most successful aircraft. Recent types with which he was connected, apart from the Tudor, were the Lincoln heavy bomber and the York aircraft. For his services to his country during the late war, Mr. Chadwick was made a Commander of the Order of the British Empire in 1943. He was elected a Fellow of the Royal Aeronautical Society in 1917 and a Fellow of the Royal Society of Arts in 1938.

MR. A. SOUTHWORTH.

We note with regret the sudden death of Mr. Albert Southworth, which occurred on August 20, at his home in Sutton Coldfield, near Birmingham. Mr. Southworth, who was only in his 48th year, was the chief engineer of the Witton Engineering Works, Birmingham, of the General Electric Company, Limited. He received his technical education at the University of Liverpool and held the degree of B.Eng. He served his apprenticeship with Messrs. Dick Kerr and Company, Limited, and after serving in the Army during the war of 1914-1918, he returned to that company as a designer, specialising in traction. Mr. Southworth joined the staff of the General Electric Company, Limited, in 1936, as chief of the traction-motor design department. During the recent war he was engaged exclusively on secret development work in connection with large searchlights, radar, and fire-control problems. He was promoted chief engineer at the Witton Works in September, 1945, in succession to the late Dr. M. L. Kahn, and since that appointment had been actively engaged on the design of large alternators to meet the national requirements for generating plant. Mr. Southworth had just returned from a visit to the United States, in the course of which he had inspected modern generating stations and other electrical plants. He was elected to associate membership of the Institution of Electrical Engineers in 1931 and transferred to the class of member in 1945.

Test Flight of Bristol Helicopter.—The Bristol type-171 helicopter made its first test flight this month at Filton. Designed by Mr. R. Hafner, head of the company's helicopter department, the machine is the first rotating-wing aircraft to be built by the Bristol Aeroplane Company, Limited. It is intended for use as an air "taxi" or a feeder-line aircraft, or for rescue work, and provides accommodation for four persons, including the pilot. The helicopter is fitted with a 450-h.p. engine and has a range of some 200 miles and a normal cruising speed of 100 m.p.h.

PROGRESS IN MODERN ENGINEERING.*

By Sir William Halcrow.

One is accustomed to think of the Industrial Revolution as a period of tremendous development, but it was really a period of tremendous invention and immediate application. In general, the pace of development was slow up to about the beginning of the present century, and did not become really fast until after the first World War, when our society had become mechanically minded. Naturally, British development has been influenced by that in other industrial countries, especially over the past 20 years; and in certain important aspects American influence was predominant, as, for example, in the development, utilisation and organisation of mechanical plant. It is proposed to treat briefly the factors which affected American progress, because our position in the future is going to be in the nature of a compromise between the American and the European traditional conditions.

In order to utilise their vast and rich continent with the limited manpower available, the Americans were faced with the greatest problems of space and scale and, while they had European technical ability, they were not subject to the influences which perpetuated European traditional methods. The natural raw materials of civilisation were available in vast quantities, cheaply, and it is not surprising that three main principles were evolved: (*a*) that large works require large efforts of either animate or machine power; (*b*) that, raw materials being cheap, it is cheaper to discard and renew than to mend; (*c*) the necessity for action. Even to day it is said that America has no craftsmen in the European sense, as few things are repaired. The first two principles have resulted in the evolution of a great range of ingenious plant units for all sorts of engineering purposes, and considerable self-confidence in the handling of engineering problems. The blessings of attitude (*c*) are not always unmixed, and it is probable that attitude (*b*) will require modification as the American continent becomes more saturated economically.

It can be fairly said that the use of steam power for industrial purposes was well developed in this country by the early years of the Nineteenth Century. By 1816, there was a regular steamship service between Great Britain and Ireland, and by 1830 factories were mechanised and railways operating successfully. There was even a useful number of steam coaches on the roads before this method of transport was crushed by railway interests and a set-back in road development of at least 50 years was caused. Limitations were mainly those of constructional materials, and the history of steam engines from that period up to the present is mainly one of improvements in efficiency and detailed design accompanying improvements in materials.

No history of recent civilisation is complete without the story of the steam railways which greatly helped to make its development possible. The railways were initially conceived as a means of transport for heavy goods traffic. The carriage of passengers soon became a lucrative adjunct, but it was not the major factor during the formative years. It was during this period, that is, until late in the Nineteenth Century, that operational methods were developed, and it must be agreed that the railways were an undoubted success. By the end of the last century, the country was covered with a network of tracks on which a fast and reliable service was maintained. The momentum of this successful development carried the railways on until well into the present century, but by this time, however, the conditions of our civilisation had altered radically and it seemed likely that the railways might suffer under Darwin's Law of "Evolve or be superseded." Population had increased rapidly and punctual passenger transport on a large scale had become a major factor in organised society.

For railways to survive in a modern world as passenger carriers, improvements in at least three directions are necessary. (1) Better technique and equipment for the clearance of breakdowns are long overdue; it is possible that frequent lay-byes and passing places will be required. (2) The block signalling system appears to be somewhat "remote" for modern load intensities. (3) The dead load of rolling stock approaches a ton for every passenger carried, which is much too high for flexibility. All these improvements involve heavy capital expenditure, but it will have to be spent or other forms of transport will inevitably take over.

Reciprocating steam engines revolutionised sea transport, and it is only in recent years that Diesel engines have tended to replace the simple and cheap coal-fired steam engine, mainly on the grounds of much reduced bunker space and boiler-room staff. Everyone is familiar with the classical turbine toy of Hero of Alexandria in 120 B.C., and since that

* Presidential address to Section G of the British Association, delivered at Dundee on Thursday, August 28, 1947. Abridged.

time there were sporadic productions of similar machines making use of the reactive powers of steam. In 1784, James Watt took out a patent for a reaction turbine, and there were several others about the same period. None of them became operational, as the engineering development of the period did not allow of the high speeds associated with such machines, and no real development took place until about 1884, when Parsons and De Laval produced the reaction and impulse turbines in a practical form. Since then, development has continued logically and consistently until we have now individual machines producing several hundred thousand horse-power each and probably at their peak efficiencies. Steam turbines suffer from the same drawbacks as reciprocating engines in that the ancillary equipment for the production of steam is both bulky and heavy, and it is natural that their main application should be in relatively static positions. They have been intimately connected with the industrial generation of electricity and propulsion of the larger and faster ships, though attempts have been made to use small turbines for flexible purposes, without much advantage being gained so far.

Although there were earlier engines, it was not until 1860 that Lenoir produced the first really successful gas engine. This was a double-acting machine with electrical ignition, and by 1862 de Rochas had formulated the theory of the modern internal-combustion engine. Soon after this, the famous series of Otto gas engines were produced. Daimler was impressed by the weight penalty involved in these engines, and, in 1884, he designed a small petrol engine for use in propelling cycles. As mentioned before, the early steam road vehicles were swept off the roads by discriminatory laws and practices, and the early petrol-driven vehicles did not overcome this opposition until 1896. The whole value of the petrol machine was in its speed and flexibility, but fuel technology and roads were so primitive that progress was very laborious. By the time of the first World War, however, the petrol engine was in a position to do considerable work in lorry transport, light ships and in aircraft, and is now, of course, a major item in our civilisation.

Towards the end of the Nineteenth Century, another kind of piston engine was being developed. Both Akroyd-Stuart and Diesel realised that the improved efficiency resulting from higher compressions could be logically carried to the stage when the high compression could cause the fuel to ignite spontaneously. Lower-grade fuels could be used and better torque characteristics obtained. Disadvantages were the heavy weight due to the high pressures and severe vibration. Development proceeded very slowly up to the first World War though a few Diesel-driven ships were in operation. After that war the momentum of development increased, and in the 1920's small high-speed Diesels were under development for road transport.

Civil engineering construction finds considerable use for engines of from 5 to 150 h.p. and, except when electricity is available, they now form the greatest part of civil engineering power units. The modern technique of large open excavations depends to a great extent on the fine range of Diesel excavating machinery developed by the Americans. The bulldozer is now legendary and, with its probably more useful cousins the tractors and scrapers, it is symptomatic of the American approach to their own problems of space and time.

The gas turbine is much in the news at present as applied to aircraft propulsion. Again, we must note that the initial lead dates at least from 1873 when Stoltze, of Charlottenburg, built a 200-h.p. gas turbine. Since then various types of experimental gas turbines have been produced, but efficiencies were low and the real development has taken place in the past few years of war in connection with air transport. In a year or so, aircraft propelled by gas turbines will be in economic operation in some numbers, and it is interesting to note that this tremendous pace of development has a general application and is representative of the scientific awareness of our society to-day. The difficulties so far have been in consistency of combustion and in heat-resisting materials for turbine rotors and blades. Both difficulties have been overcome to a great extent; the former by detail design and the latter by various nickel and nickel-chrome alloys, with the use of ceramics probable in the future. Immediate future development will probably be directed towards the improvement of thermal efficiencies.

The famous water wheel, which preceded the steam engine as the main prime mover, is practically extinct in this country, even for rural industry. This is not so over great areas of the world, and there are some countries, like China, the rehabilitation of which depends greatly on the stimulus of some simple inanimate source of power. For most industrial uses, however, several forms of turbine have been evolved to deal with various quantities of water at various heads. For high heads the main turbine is the Pelton wheel, for medium heads the Francis turbine, and for low heads the Kaplan, a variable-pitch propeller machine. The turbine conception is over 100 years old, and in 1840 Boyden attained an efficiency of 88 per cent. by careful design of an outward-flow machine. Present-day efficiencies are a little over 90 per cent., and the history of these machines since about 1850 is one of improved materials, construction and control rather than of major invention.

In this country, until quite recent times, hydro-electric development was a relatively small proportion of the total power output; now, the development of Highland water power has been centralised under the North of Scotland Hydro-Electric Board and a considerable number of schemes are either under construction or under consideration. As many of these schemes will be connected to a grid including steam stations, a potential operational development is involved in that schemes with little natural storage become feasible through the overall regulatory effect of the steam plant. This grid regulatory effect may also be of major importance in the great tidal-power schemes like the Severn Barrage, where 2,300 million units per annum can be generated at a cost of 0·2*d.* per unit at the switchboard. The scheme envisages an installation of 32 machines giving 800,000 kW at a total cost of 40,000,000*l*, and could be constructed in seven or eight years.

Electricity is the great linking agent of our civilisation. It enables the power produced by our prime movers to be distributed and used with magnificent flexibility, and has made possible a whole host of light industries. Most of our organised life is carried out by its aid. I will refer only to some of the ever-widening applications of the properties of the electronic valve. It would seem, in retrospect, that the use and success of these valves in wireless work rather blinded us to their potentialities in other aspects. Fundamentally, the valve is only a sensitive device for magnifying an oscillating electrical signal, and we may have been conditioned in the past to think of this signal as being always associated with the radiation of wireless waves. Within the past ten years, we have seen the supersession of many mechanical methods by the use of electronic devices for all sorts of automatic controls, ranging from the temperature control of crucibles and furnaces to electronic "brains" for the solution of mathematical problems. Indeed, there can be very few mechanical control processes which cannot be performed much more compactly by an electronic device.

Our mechanical civilisation did not attain a high rate of progress until iron and steel could be produced cheaply in large quantities, and it was not until the period 1870-90 that the necessary outburst of metallurgical science took place. Prior to this, the production of iron and steel was more an art than a science, although the famous Iron Pillar of Delhi was probably made about A.D. 300. This is a large forging of almost pure iron, 24 ft. long and 6¼ tons in weight. In 1722, Reaumur described how to convert bar iron to steel, and the cementation process for puddled iron; and by 1740, Huntsman had developed the production of crucible steel at Sheffield. In 1786, Cort was producing bar wrought iron by rolling with grooved rollers. It is quite probable, therefore, that many of the modern production methods for the metal were known before the beginning of the Nineteenth Century. By 1829, the annual output of pig iron in the United Kingdom was 690,000 tons.

The production of cheap steel became possible only in 1856, when Bessemer published his blast-furnace technique and the Siemens Brothers their open-hearth method. By the last quarter of the century, Sorby, with his microscopic analyses of the crystal structure of iron and steel, had made the science of metallurgy possible. At the turn of the century, steels of high and consistent quality were available, and a greatly expanded range of engineering structures became possible. The present century has seen the great development and production of the alloy steels.

(To be continued.)

ENGINEERING AND MARINE EXHIBITION, OLYMPIA.—The London Passenger Transport Board are running a special service of District Line trains between Earl's Court and Kensington (Olympia), for the duration of the Engineering and Marine Exhibition, from August 28 to September 13. Trains run every ten minutes, the first leaving Earl's Court at 10.8 a.m., and the last departing from Kensington (Olympia) at 10.8 p.m.

THE LATE MR. G. W. CLARKE.—We regret to record the death of Mr. George W. Clarke, which occurred after a short illness on August 16. Mr. Clarke, who was 62 years of age, was a specialist on gear and spline grinding, and had served on the staff of Messrs. Wickman Limited, Coventry, since 1938. Prior to this, he was works superintendent of the Gear Grinding Company, Limited, Birmingham, and had been responsible for many large installations of gear and spline-grinding plants in aircraft and motor-car factories throughout Europe. Notable among these was the complete installation of all gear-grinding equipment at the Fiat Works, in Milan, which he undertook in 1934.

THE WORK OF THE ROYAL INSTITUTION IN PHYSICAL CHEMISTRY.*

By PROFESSOR ERIC K. RIDEAL, D.Sc., F.R.S.

THE Royal Institution is a foundation "for the promotion of science and the diffusion and extension of useful knowledge," and is best known throughout the world as the place where Michael Faraday lived and worked. It was, indeed, Faraday who imparted to the Institution its peculiar characteristics, which combine those of an academy, a club and a research institution. Research in chemical matters in the Royal Institution may be said to have commenced with the appointment of Humphry Davy in 1801 as Lecturer in Chemistry, and shortly afterwards as the first of the resident professors. Faraday was appointed first Fullerian Professor of Chemistry in 1833 and had as his successors Odling of Oxford (1868), Gladstone (1874), Sir James Dewar (1877), Sir William Bragg (1923) and Sir Henry Dale (1942). Other professors of chemistry have been W. T. Brande and Sir Edward Frankland, and the professors of natural philosophy who have extended the knowledge of physical chemistry by experimental work in the Institution include Thomas Young, John Tyndall and Lord Rayleigh. Five of the professors in the Royal Institution have been Presidents of the Chemical Society.

The founder of the Royal Institution, that remarkable American, Benjamin Thompson, afterwards Count Rumford, included in his investigations not only the mechanical equivalent to heat, but also the principles of thermal isolation, and of the reflection and radiation of heat. Sir Humphry Davy published a number of papers on radiant heat and Thomas Young, who was Professor of Natural Philosophy at the time, developed the undulatory theory of light and interpreted the phenomena of optical interference. Later, Tyndall, in his study of the diathermancy of gases and vapours, contributed much to the knowledge of the infra-red and to the scattering of light by particulate matter; and Lord Rayleigh's interferometer is now one of the most important physico-chemical instruments. The Rayleigh laws of light-scattering are now being applied to the determination of the size and shape of disperse matter, especially polymers. This work on radiation was followed by that of Sir Joseph Petavel on the measurement of the intensity of radiation at high temperatures, the determination of the melting point of platinum, and the development of the bolometer.

Another interesting case of continuity of work is to be found in connection with the phenomenon of condensation and liquefaction, starting with Davy's interest in this problem, which resulted in the liquefaction of chlorine by Faraday, who subsequently liquefied other condensible vapours and gases. Faraday failed to liquefy the more permanent gases, but this work was taken up with great success by Sir James Dewar, whose work on low temperatures included the determination of specific heats at low temperatures, the absorption of gases by cool charcoal and other absorbents, and the principles of thermal isolation, all of which have had important consequences. It is not clear whether Dewar was the first to make use of the hot-cold tube method used so successfully by his contemporary Sainte-Claire Deville and afterwards by Nernst and Wartenburg, but he describes the thermal formation of ozone by this method.

The work of Davy on electrochemical decomposition, which founded the modern electrochemical industries, was followed by the quantitative work of Faraday, resulting in the fundamental laws of electrolysis. Dewar contributed work on the reactions in the electric arc and in the silent electric discharge. His work on nitrogen fixation in the form of hydrocyanic acid and cyanogen, is worthy of note. It was in the Royal Institution that Rayleigh's investigation on the densities of gases and the isolation of argon was carried out. The thermal formation of nitric oxide was not the least important part of this work. Cuthbertson's determination of the refractivities of the rare gases and Wahl's optical investigations on solidified gases were likewise carried out there. Davy's work on firedamp, resulting in the miner's lamp, finds application to-day in the construction of explosion barriers. It is also worth recording that Davy made the first photographic (profile) prints.

Faraday's active experimental life extended over a period of some 40 years, during which period no less than 15 major investigations were undertaken, each of them having a profound effect on physical chemistry. It is worth while to set these down, as under:

1820 Alloys of steel.
1821 Electromagnetism. Magnetic rotation.
1823 Liquefaction of Cl_2 and other gases.
1825-6 Isolation, analysis and sulphonation of benzene and naphthalene.

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* Lecture delivered at the Royal Institution on July 16, 1947, in connection with the centenary celebrations of the Chemical Society. Abridged.

1825-9 Optical and heavy glass.
1831 Vibrating surfaces and magneto electricity.
1834 Electrochemical Laws. Electricity in the Voltaic pile. Catalysis.
1837 Frictional electricity. Specific inductive capacities.
1845 Magnetism.
1849 Diamagnetism and light. Magnetism of flame and gases.
1851 Colloidal gold.
1860 Regelation of ice.

It is probable that Tyndall, when studying the moulding and flow of ice, had Faraday's work in mind. Tyndall's work on glacier movement forms the basis of the modern treatment of this subject, and Barnes extended the knowledge of the crystal structure of ice in the same laboratories. Dewar also was interested in the flow of substances under pressure, but made no notable contribution to the subject, except to record the effect of high hydraulic pressures on many chemical substances.

Gladstone made a number of important contributions to science. His early work consisted in evaluating the molecular refractions of a number of compounds from which he, together with the Rev. Dale, defined the concept of atomic refraction and compiled the first table of this physico-chemical property. He likewise, in the development of his well-known zinc-copper couple, made a number of important observations; for example, that there is scarcely any liberation of hydrogen when magnesium is brought into contact with pure water, but, on addition of a trace of a copper salt, a vigorous reaction sets in. He published a number of illuminating drawings of the form of silver crystals growing from silver nitrate to which copper had been added, and of tin growing from stannous chloride in the presence of zinc. He showed, furthermore, that the zinc-copper couple would not only decompose water, but also the organic halides, and describes zinc ethyl as spontaneously inflammable. Dewar carried out a series of experiments which, at that time, were important in establishing the principles of reversibility. Together with Scott, he determined the vapour densities of sodium and potassium, and the vapour densities and dissociation of hydrazine hydrate and mercuric cyanide.

W. J. Russell worked on the theory of the photographic plate, his Bakerian lecture of 1898 being devoted to this subject. It is significant that Clerk Maxwell, in a Friday Evening Discourse in 1861, adopting Young's theory of colour vision showed the first three-colour photograph of a piece of ribbon; this formed the basis of the three-colour process. Other early workers in physical chemistry include Sidney Young on fractionation, George Senter on electrolysis and hydrolysis rates, Wildermann on photo-voltaic effects, and Tizzard on hydrolysis. If the determination of atomic weights is to be included under the title of physical chemistry, the Royal Institution is well represented by the 15 communications of Alexander Scott on this subject, which included carbon, nitrogen and tellurium and the combining ratio of carbon monoxide and oxygen. With the advent of Sir William Bragg, the Davy-Faraday Laboratory became the centre of research in X-rays and crystal behaviour. There are few universities in this country where the torch of this learning has not been carried and where it is not still furiously burning. Other workers in the laboratory during this period included Astbury, Bernal, Caspari, Childs, Cox, Gibbs, Miss Knaggs, Mrs. Lonsdale, Mattieu, Robertson, Robinson, Shearer and Weiss.

In conclusion, I must mention the name of Alexander Muller. Muller was admitted to the Davy-Faraday Laboratory in 1923 and, during the past 24 years, has pursued his work on the application of X-rays. He will be especially remembered by chemists and physicists for his now classical work on the measurement by X-rays of long-chain compounds, and by engineers and designers for his development of the spinning target generator. In the laboratory, a 50-kW machine is a memorial and witness to his great skill both as a designer and experimentalist. Those who knew Muller had a great affection for him. If ever a worker had absorbed the spirit of the Davy-Faraday Laboratory of the Royal Institution, it was Alexander Muller.

The Air-Speed Record.—The United States naval authorities have announced that a Douglas Skystreak aircraft has attained a speed of 640·7 miles an hour, and thereby has broken the record of 623·8 miles an hour set up in June of this year by the United States Army Air Forces with a Lockheed Shooting Star, a brief account of which was given in Engineering, vol. 163, page 551 (1947). The aircraft was piloted by Commander Turner F. Caldwell, and the flights were made at Muroc, California. In its standard form the Skystreak is a single-jet machine in which the turbine is installed in the centre of the fuselage, the jet nozzle being situated in the tail of the machine.

LABOUR NOTES.

In the report which they have prepared for submission to the Trades Union Congress at Southport, the General Council state that their 40-hour week committee had expected an approach to the Government early in the year. Reduced normal hours of work and the form of legislation which would be required to secure acceptance of the 40-hour week throughout industry was to have been discussed. During the year, however, the industry of the country had to face difficulties. "The problem caused by the fuel crisis, the severe winter, and the increasing speed at which the dollar credits were being used, necessitated," the report goes on, "the initiation of discussions between the General Council, through its special committee and the Government, at which a wide range of industrial problems, including the question of reduced hours, was given consideration. During the period of these comprehensive discussions, it was considered that a further approach to the Government by the 40-hour week committee on the isolated problem of reduced hours of work would have been inappropriate."

"At the conclusion of their discussions with the Government," the report continues, "the special committee decided to hold further meetings with unions, representing individual industries or groups of industries, in connection with a consideration of the economic situation and the Government's White Paper. The 40-hour week committee noted that it was intended to hold meetings to discuss rail transport and railway workshops, electricity generating and the manufacture of equipment, iron and steel, gas, coal, building, agriculture, cotton, and wool. At the meeting of the 40-hour week committee in June, it was, therefore, decided to defer the approach to the Government on the subject of legislation to facilitate the implementation of the 40-hour week until after the results of these meetings were available and had been given consideration."

Accounts of the proceedings at a series of meetings with the Minister of Supply on the subject of nationalising the iron and steel industry are recorded in the General Council's report. It is stated that at the last meeting, in July, Mr. Wilmot had informed the committee that a Bill dealing with the matter was being drafted but would not be completed before the Parliamentary recess.

There are two resolutions on the Southport agenda on the subject of nationalising the steel industry. One by the Amalgamated Union of Foundry Workers asks the Government to give "urgent attention" to nationalisation of the industry, and the Constructional Engineering Union calls on the Government "for a steel nationalisation Bill during the forthcoming session."

The Electrical Trades Union declares, in a resolution, that the shipbuilding and ship-repairing industry has a major role to play in the restoration of the country's prosperity, and that, as a matter of immediate importance, and a pre-requisite to full production, there should be the fullest investigation by the Government into its production methods, with a view to the co-ordination and standardisation of its operations. In order to guarantee full employment, it is added, there should be the provision of alternative work for the shipyards as and when the immediate replacements needs are met.

At a meeting last week, the Agricultural Wages Board confirmed the recent decision to increase the wages of agricultural workers in England and Wales. The new rate for men is 90*s.* for a 48-hour week. For women, the minimum is 68*s.* for a 48-hour week, and in four areas where women's wages are related to a 44-hour week, it is 62*s.* New rates for young men are: age 20, 79*s.*; age 19, 72*s.*; age 18, 65*s.* Young women between 18 and 20 get 62*s.*, and part-time workers 1*s.* 11*d.* an hour for men and 1*s.* 5*d.* an hour for women. The new rates are to be payable as from August 31.

According to an announcement made by the Treasury on Thursday last week, an agreement has been reached on the wages claim of the Civil Service Alliance. The general effect will be that shorthand-typists will receive an increase of 6*s.* a week, typists one of 3*s.* a week, temporary clerks (men) one of 6*s.* a week, and temporary clerks (women) one of 4*s.* 6*d.* a week. Established clerks (men) will get an increase of 20*l.* a year, and established clerks (women) an increase of 15*l.* a year. The new scales are to be effective as from July 1.

The section of the Transport and General Workers' Union's *Record* dealing with the metal and engineering industries, states that the two sides of the wire and wire-rope trade have agreed to form a Joint Industrial Council. Both the employers and the unions are now considering the appointment of representatives to the Council in order that the new negotiating machinery may operate "at the earliest possible moment."

An agreement reached by the Transport and General Workers' Union with the employers in the iron, steel and non-ferrous metal scrap industry provides for a reduction of the working week from 48 to 44 hours without loss of pay. It is to become operative on the first pay day in the week commencing October 6. The question of working the reduced week in five or five-and-a-half days is to be decided locally by mutual arrangement. An agreement on the subject of working hours has also been reached with the agricultural machinery and tractor dealers. Under it, the week is reduced from 48 to 45 hours. In the metal-finishing industry, it has been agreed to reduce the working week from 47 to 44 hours. Hourly rates have been adjusted in order to avoid any loss of pay.

At last week's resumed conference on the subject of temporarily increasing working hours, between the National Coal Board and the National Union of Mineworkers, there was again failure to agree and the matter was referred for consideration to the Cabinet. A communication issued after the meeting with Ministers stated that "the union representatives had indicated that the full implications of the five-day week agreement are accepted and that steps will be taken in conjunction with the Coal Board to bring about an increase of stints when this is possible and to bring to an end all restrictive practices." A stint, it may be explained, is an area of coal face allotted to be cleared during one shift.

The union representatives, the communication continued, "further undertook to discuss with the Board methods for dealing with habitual absentees, including, if necessary, the application of penalties, and to consider the attachment of conditions to the payment of the guaranteed weekly minimum wage in cases where a joint committee of representatives of the union and the Coal Board are satisfied that there has been organised restriction of effort. No agreement was reached during these discussions on the conditions to be attached to the extra time."

The main issue between the parties originally was concerned with the method of increasing the weekly hours of work. Mr. Attlee's suggestion was that an extra half-hour a day should be worked, while the executive of the Mineworkers Union preferred the working of at least two Saturday shifts a month. The miners later amended their proposal by offering to work every Saturday until the coal situation began to improve. The Coal Board declined to accept the offer unless it was agreed to make Saturday working compulsory to qualify for the bonus shift payment miners are getting under the five-day week agreement. The Board desire a similar condition to apply, even if the Prime Minister's suggestion is adopted. The miners' leaders refused to accept these conditions, and their decision was endorsed by a National Delegate Conference which met in London on Friday last.

A resolution adopted by the National Delegate Conference "recognised" that failure to increase coal production would retard the efforts of the Government and make for lower British living standards. The resolution added: "The conference deplores the action of a minority within the industry in continuing those practices which are contrary to the spirit of the five-day week agreement, and re-affirms the determination of the membership fully to implement the undertaking given by the union in relation to the re-assessment of tasks, the introduction of measures for dealing with habitual absentees, and the cessation of all restrictive practices." On the major issue of working hours, the executive committee was authorised "to continue negotiations and report to another national conference."

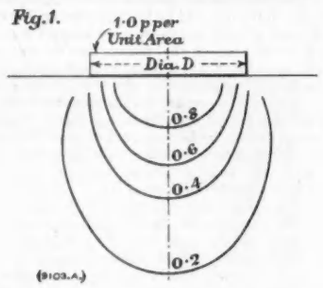
The tribunal set up to consider the claims for wage increases and improved conditions of provincial omnibus workers, employed by private companies, issued its award last week. The award provides for a national agreement on the subject of conditions, a guaranteed 44-hour week for regular staffs, a minimum of seven hours work a day, time-and-a-quarter for the first two hours of overtime, and time-and-a-half afterwards. There are also to be improved spread-over payments, time-and-a-half for work on four Bank Holidays, and a day off in lieu of working, improved payments for work done on rest days, and ten days annual holiday with pay. The award, subject to the approval of a national delegate conference, is to take effect not later than September 15.

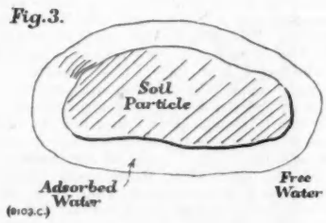
ANALYSIS OF THE POSITION IN SOIL MECHANICS.*

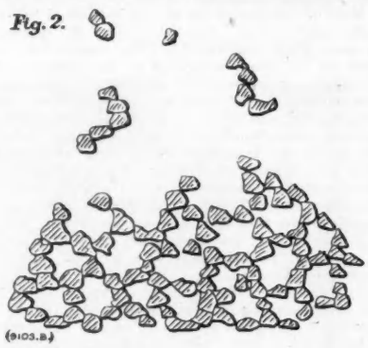
By N. J. COCHRANE, B.Sc., A.M.I.C.E.

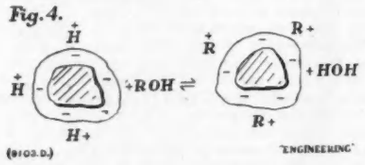
IN the history of many of the great problems confronting organised society there appear to be three general stages. The first stage is that of relative ignorance where we recognise, and avoid if we can, the possibility of serious effects from a certain course of conduct. In engineering, this is the "design by experience" stage wherein is perpetuated the wisdom, sometimes involving extravagance, of earlier times. The second stage is that of more knowledgeable analysis, wherein the mechanics of the problem is gradually unveiled and a rational structure begins to appear. The third stage quickly follows, and is that of control, wherein we either develop methods of handling the original problem so that it no longer constitutes a menace to us, or we may change the original conditions in some way so that the problem is radically changed and eased.

It can be said, roughly, that the great engineering problem of working with the soft materials of the earth's crust has passed through the second stage and a considerable way into the third in the past 30 years.









There is now little justification for unforeseen mishaps when the handling of soft materials is involved, as the technique of investigation is well established and the analytical tools are simple enough to be used by the practising engineer with reasonable economy of effort and time. A great part of the credit for this great surge of research and application must go to Dr. Karl Terzaghi, who started to set out the important factors in soil mechanics with great clarity just after the first World War, and who has remained in the forefront of soil scientists ever since. In this short paper, the author will attempt to set out very briefly the present state of knowledge in this subject and to point out some of the ways in which advances are being, or may be, made. For convenience, soils will be divided into the coarse-grained or non-cohesive type and the fine-grained or cohesive materials, though in actual fact the division is not sharp.

One problem common to both is the estimation of stress distribution below a loaded area. Deriving from Boussinesq's solution for a point load at the surface of what is laboriously but accurately termed a semi-infinite elastic continuum, i.e., one which is homogeneous and elastically isotropic, the stress patterns for a range of simple type loads have been tabulated. Although such an idealised material is not met with in practice and local stresses at the boundary of the applied load depend on the stiffness of the foundation, the general picture is often accurate enough for the purpose Several important problems are not susceptible to close mathematical analysis, and, if a close analysis is necessary where complicated load systems are involved, the only practical approaches open are by two or three dimensional photo-elastic analysis, or by using St. Venant's distant boundary principle and then applying Professor Southwell's relaxation methods. Stress conditions under a circular loaded area are shown in Fig. 1, and it can be readily seen that no important percentage stresses are induced in the supporting material below a depth of, say, twice the breadth. This is a geometrical relationship and it leads directly to the conclusion that many field tests on small test areas are worthless, as soft materials may have a much stronger oxidised and dried crust which is probably not penetrated by the stress pattern. This diagram also shows how far it is necessary to strengthen the material underlying a load as, say, the sub-grade of a runway or road.

In general, non-cohesive granular materials do not present insoluble problems to the engineer. Settlement under load is usually small and quickly complete and its general characteristics are too well known to repeat here. There are, however, certain phenomena and techniques which are not so well known or understood, and the range of usefulness of which may be far from exhausted. The existence of internal "arching" is well known, and this factor can be used in the design of relatively flexible tied retaining walls. Although the total thrust remains of the order of the Rankine thrust, the pressure redistributes itself by tending to concentrate at the hard points—say, at the tie-rod connections and the toe. Considerable reductions can then be made in bending moments in the middle of the wall. Non-cohesive filling can be used as a structural material in self-supporting cellular cofferdams. These have been used in America and on the Continent for large works and, when the cost and trouble of timbering even a small normal cofferdam is considered, it is clear that they would not suffer from a re-examination of their economics.

Some of the biggest problems in handling coarse-grained materials are in dealing with water. When water-retaining structures are involved, the percolation of water around the structure may have to be considered. This is susceptible to mathematical flow-net analysis but, as the laws of hydraulic seepage are analogous to those of electrical flow, it is advantageous, in some cases, to use electro-potential experimental methods so long as the boundary conditions are correct. Indeed, where questions of design are concerned, the simplicity and flexibility of the electrical method has many advantages and can give both qualitative and quantitative results.

Where it is not possible to deal with a water problem by pumping, as in, say, a tunnel driving into a water-logged ballast, it is often possible to change the material into a concrete by the injection of cement grout, or into an artificial rock by the injection of chemicals. These are usually sodium silicate and calcium chloride. If a waterproof screen is required, injection of finely divided bituminous materials has been successful in clogging the pores of the soil. Several other materials spring to mind which would perform the same function, and it has been possible to synthesise resins in situ on soil particles.

Another range of problems is met with in the consolidation of filling to form the subgrades of roads, runways, etc. In this country, as in America, the required compaction is achieved by what must be classed as the method of force, in that it involves the use of heavy rollers, some metal-surfaced, some rubber-tyred, and some sheep's-footed. The ever-increasing load demands have resulted in ever-increasing sizes of rollers, and some of the latest American rollers range up to 200 tons in weight. There are, of course, other and perhaps easier ways of achieving the compaction of materials, and methods of vibration have been developed in Germany to a considerable extent. It is only necessary to observe the effect of even the most unscientific of vibrators on a very stiff mix of concrete to realise the capabilities of this method of consolidation. Technical information is not yet easily obtainable on the Degebo investigations on sandy fills, but it appears that the action is not very sensitive and useful consolidations can be obtained within the range 0·5 to 1·5 times the natural frequency of the soil vibrator system. There is still work to be done on the technique, but in view of its possibilities it does not appear to have received sufficient attention in Britain and America, although there have been sporadic investigations.

In fine-grained cohesive materials the civil engineer meets some of his greatest problems and a large part of soil mechanics research has been devoted to their solution. We can now forecast settlements under load, duration of settlement, and analyse the stability of some types of load system and arrangement with reasonable accuracy. A clear idea of the general formation and structure of clays is necessary, however, if we are to control the material in a positive manner.

Cohesive materials are mainly formed of soil particles of colloidal size, or near enough to colloidal to act similarly. These particles would remain in suspension in water indefinitely because of the Brownian movements until their electric charges were neutralised by an electrolyte, as, for example, when a river enters the sea. Flocculation then takes place and the flocs sink to the bottom. The mass of individual particles is so small, however, that the intermolecular bond forces become important and the sediment is of a loose spongy nature with the particles sticking to each other as in Fig. 2, and not rolling over each other. Water is entrapped in the spaces of the sponge or honeycomb, and, as the deposit builds up, the lower layers become compressed by the squeezing out of the water. It will be realised that these spaces are very minute and consequently the water tends to behave as in thin capillary tubes. The soil particle is encased, as in Fig. 3, in a thin film of adsorbed moisture, which is very strongly held and ranges from an almost free water in the outer fringe to what is probably a semi-solid substance in the inner layers. Changes in temperature may cause considerable variation in film thickness. In addition, the soil is classified according to which ion is adsorbed to it. The charge on the soil particle is given by that of the inner layer of the adsorbed film and determines which ion shall be adsorbed. If negative, as is generally the case with clay, cations will be adsorbed and if positive, anions. If, say, a hydrogen clay is leached through with hydrated lime, $Ca(OH)_2$, the calcium replaces the hydrogen to form a calcium clay and the released hydrogen combines with the $(OH)_2$ to form water, but an ionised clay can only exist after the ionising salts have been leached out by water and, say, a calcium clay has not necessarily the same properties as the same clay containing calcium salts.

This conception of the structure of clays and allied materials clearly defines their behaviour. Settlement and consolidation, being effected by the squeezing out of water, can only take place slowly, as the pore spaces are so small. Adsorbed water coating the soil particles, apart from further effectively reducing the size of the pores, is not free water and normal methods of drainage do not affect it. It is believed also that the bipolar nature of the molecules which are adsorbed to the soil particles is responsible for the plastic characteristics of clay. When soil is mixed with a liquid like carbon tetrachloride, which is not bipolar, no plastic characteristics are in evidence. Further, the replaceable ion which classifies the type of clay has a big effect on its elastic and swelling properties. For example, a sodium clay has very different characteristics from the same clay ionised with aluminium. Again, if we break down the physical structure of the clay by remoulding or vibration, its strength is greatly reduced and is only gradually re-established. This is the special characteristic of the thixotropic clays. There is the fairly well known case of some piles at Shanghai which entered the ground under their own dead weight and that of the hammer—a matter of, say, 4 tons. After a period of rest their bearing resistance had built up to 11 tons.

At this stage we should recapitulate the two types of control: either we accept the material as we find it and design the foundations of our structures so as not to overstrain the material, or we devise some method of strengthening the natural material. The former alternative is the normal process at present and often involves an immense economic burden. The latter alternative is uncommon in this country. However, it is not insoluble and more than ten years ago certain interesting research work began to be published. The last war has eaten up much of the intervening period, but the researches of Dr. Leo Casagrande are now available to this country.

There are two approaches to the strengthening of soft materials: they may either be drained and consolidated by their own weight and capillary forces, or they may be altered somewhat in chemical structure, say, by base-exchange as mentioned above (see Fig. 4) or by forming insoluble compounds in the interstices of the soil.

* Paper read before Section G of the British Association at Dundee, on August 28, 1947. Abridged.

As the adsorbed film or double layer is negatively charged, we can detach it from the clay particles and cause it to flow along an electro-potential gradient. The free water tends to be carried along with it. This is the principle of electro-osmosis, and, by a suitable arrangement of electrodes with well points, water can be drained from the soil. Several successful applications of the principle are on record, although they made more use of induced hydraulic gradients for temporary structural purposes than of the ultimate dewatering of the soil.

Assuming we had dewatered, consolidated and strengthened the soil by electro-osmotic drainage, we should still have to ensure that it could not be softened again by external water, and research work on electro-chemical hardening has shown interesting results. As mentioned before, differently ionised clays have different characteristics, and it is possible by base-exchange to change one type of clay to another and so alter its properties. In 1936, Endell and Hoffman published the results of a Casagrande-type experiment in which aluminium anodes were used to pass an electric current through an almost liquid sodium clay. It was found that the clay in the vicinity of the anodes changed its character radically and became very stiff. In fact, it had been changed to an aluminium clay with very stable characteristics and, in addition, it was believed that deposits of aluminium compounds in the clay had added to its strength. Of course, the two processes of electro-chemical hardening and electro-osmotic drainage can be carried on at the same time.

LOW-CARBON MOLYBDENUM STEEL.

MOLYBDENUM is one of the elements which, when alloyed with iron, restricts the γ region of the system, and the critical concentration of the element is approximately 2·7 per cent. in carbon-free iron. Molybdenum, as is well known, has been widely used on account of the marked retardation that a small amount—1 per cent. or less—has on the γ to α transformation. Its use in higher percentages, to raise the temperature of the α to γ transformation so as to reduce or retard hardenability, is, perhaps, not so widely known. When a high molybdenum concentration is present in a carbon steel, the rate of the solution of the carbide phase is retarded considerably, so that, even if the surface of the steel is heated above the transformation temperature, some time will elapse before appreciable hardenability results. Low-carbon high-molybdenum steels, containing from 2 per cent. to 5 per cent. of molybdenum, have been investigated and the results obtained have led to the development of a series of steels in which molybdenum is used to prevent or retard hardenability. It is stated in a recent issue of the *Alloy Metals Review*, published by High-Speed Steel Alloys, Limited, Widnes, Lancashire, that the research department of the Climax Molybdenum Company, Detroit, Michigan, U.S.A., have done a good deal of work on this subject.

Several service tests of the molybdenum alpha-irons, as these low-carbon (0·10 per cent. to 0·20 per cent.) alloy steels appear to be called, are in progress. In some instances, it is stated, they have proceeded sufficiently to provide definite indication that the new alloys have merit where the service life of a particular component is a function of its resistance to surface thermal cracking. Thus, an alloy containing 0·20 per cent. of carbon and 3·10 per cent. of molybdenum, when used for water-cooled die liners in a hydraulic piercing press making 155-mm. shell forgings, produced 5,000 to 7,000 forgings against an average of 2,195 forgings when a steel containing no molybdenum was used for the liners. In another investigation the new material was employed in the form of dies in a 1,500-ton forging press. Tests run so far, it is stated, indicate that, here also, the 3 per cent. molybdenum low-carbon steel has excellent possibilities for the manufacture of die blocks where resistance to surface heat cracking is desirable. A third series of tests has been conducted using a 3 per cent. molybdenum steel for making moulds for producing cast-iron pipes; the material employed previously for the mould was a 0·30 per cent. carbon chromium-molybdenum steel. The tests, although at present unfinished, have shown that, provided certain minor production problems can be solved, the 3 per cent. molybdenum steel may be expected to give at least 75 per cent. longer service, on the average, than the chromium-molybdenum steel previously employed.

COMMEMORATIVE PLAQUES IN G.W.R. RESTAURANT CAR.—Bronze plaques have been fitted to the Great Western Railway restaurant car No. 9673 to commemorate its service in the war-time special train used by Mr. Churchill, the British Cabinet, British and American Service chiefs, and, in France and Germany, by General Eisenhower as part of his mobile headquarters.

SELECTIVE CORROSION OF PHOSPHOR-BRONZE.*

By W. D. CLARK, M.A., M.Sc.

THE feed-water system on the power station of the Billingham Division of I.C.I., Limited, consists of a series of four pumps, from the last of which the water is delivered at 1,100 lb. per square inch, and seven heaters, in which the water is heated to a final temperature of 200 deg. C. by steam bled at suitable pressures from a feed-heat turbine. The condensate which is formed in each of these heaters is drawn off by a separate heater extraction pump and injected into the main feed line as it leaves the heater. The feed-water consists of zeolite-softened make-up and returned condensate, and is treated with caustic soda, bisulphite and disodium phosphate, the last-named added at intervals. The average analysis is (parts per million):

Final-feed analysis	*p*H	Na_2SO_4	Na_3PO_4	$CaCO_3$	Na_2CO_3
	9·0	19·5	0·5	1·5	3·8
NaOH	Na_2SO_3	NaCl	Tannin	T.D.S.	
2·0	1·0	9·0	0·5	44·8	

The condensate contains only a little carbon dioxide and has a *p*H near 6·0, except when a heater leaks, in which case the condensate from that heater contains feed-water and is alkaline.

Most of the pumps are of the horizontal two-stage centre-suction type: the "A" and "B" pumps are of seven-stage construction. The casings are either steel or cast iron, according to the pressure. The impellers and bushes are of sand-cast phosphor-bronze, nominally of 10 per cent. tin content. The external surfaces and periphery of the shrouds are machined, but the internal surfaces of the shrouds and the vanes are given no treatment other than shot-blasting. Well over a hundred impellers are in service, and a suitable stock of spares is held. Impellers are occasionally changed for other reasons than defects in the impeller, and thus it is not always certain how old any impeller is. The station has been operating for 15 years, and it is therefore probable that most of the impellers will have had, say, 10 years service.

In December, 1944, an "A" pump impeller failed, the boss breaking out of the shroud. It was not possible to exclude a mechanical cause. Examination of the metal showed a peculiar segregation, the importance of which was not then recognised. In February, 1945, a second failure took place, on a seven-heater extraction pump. Examination made it quite clear that the water was attacking and weakening the bronze to an extent not apparent unless sections were examined. It was clear that the abnormal segregation noted on the previous failure was due to the same cause, and it was realised that other impellers which appeared in a satisfactory state might, in fact, be unsound. Opportunity has been taken, therefore, to examine all the impellers possible, both those in pumps and those in stores which had seen service. It was found that, if a small portion of the peripheral surface was polished and then darkened by etching with alcoholic ferric chloride, attack could be detected readily.

The seven-heater impellers were known to have had only four years' service. The life of the others is unknown, but is probably much longer. An impeller from a five-heater extraction pump, while superficially satisfactory, was shown to be unsound by the etching test. It could be cracked readily by a light hammer blow and up to 75 per cent. of the thickness of the shroud had been rendered valueless. In this, as in every case, the major attack was from the outside surface of the shrouds. External examination of the impellers led to the generalisation that there was no removal of metal from the surface of impellers handling feed-water, and the machining marks were unaffected. A small amount of scale adhered in patches to the outside surfaces, but very considerable deposits occurred inside. The impellers handling condensate at temperature above 140 deg. C. were considerably eroded on the external surface and had many small under-cut pits. The inside surfaces were not appreciably eroded, and carried a small amount of scale. The difference between inside and outside scaling and erosion is probably due to the fact that the velocity on the outside is several times greater than inside.

Detailed examination of attacked impellers showed a number of features of considerable interest, which will now be described with particular reference to an "A" pump impeller held as a spare, but which had probably been in service for five to ten years. The structure varied from an equi-axed cored region in the boss to a dendritic structure in the shrouds, and the metal was generally porous. Fig. 1, opposite, shows an unetched section from the periphery of the shroud. The machined surface of the shroud is at the top of the figure, and extensive attack is apparent on this side. Porosity is evident in the middle. The shot-blasted surface at the bottom of the figure shows some corrosion between the dendrites, but no attack comparable with that at the other side. Separated from the surface by a film of non-metallic matter is a metallic film.

Fig. 2, opposite, shows the structure of the attacked region, etched with ferric chloride. Between the bronze dendrites are found irregular patches of red material which are shown later to be pure copper. In Fig. 3, these areas are shown at a higher magnification, after etching with ammonium hydrate and hydrogen peroxide, and it is seen that the copper "lakes" are surrounded by a confused region containing copper and a non-metallic constituent, possibly porous. The copper areas are not porous and show internal boundaries (visible also in Fig. 2) and, in some cases, give the impression of twin bands very strongly. Up to 30 per cent. of the area of a section might be occupied by "lakes" at the outside of a shroud; the proportion decreased towards the middle of the thickness.

There was an appreciable proportion of the light blue δ-phase present, and it was clear in many areas that it was a constituent of a ternary eutectoid with α and a deep-blue phase, presumably of high phosphorus content. Little δ could be found in the region of heavy attack, and several instances were seen of δ associated with a small area of the porous red constituent; it seemed possible that δ was subject to preferential attack, but it was clear that the total content of δ was far short of that necessary to produce the copper lakes. Most of the attack had been on the α phase. The δ-phase is known to be metastable below 400 deg. C., but no evidence was detected to suggest that this was relevant to the structures seen.

On the inside of the shroud, the "as-cast and shot-blasted" surface, the structures were more complex. In Fig. 4, opposite, is shown the edge of the same specimen as Fig. 1, and Fig. 5 is also the same at higher magnification. It is seen that there is a metallic film separated from the bronze by a two-phase field, rounded areas of a dark non-metallic constituent surrounded by a well-formed lamellar eutectic (or eutectoid). The metallic film and the metallic constituent of the eutectic were both of a copper colour and the proof that the "lakes" mentioned above were pure copper was taken as applying to the film. It was difficult to develop any structure in the film owing to its thinness (0·001 in.), but the impression gained was that it contained grain boundaries similar to those in the "lakes." Not all specimens examined showed the film: some showed only traces of the eutectic, but, on the other hand, some flakes of scale were found to contain an internal film of copper.

The combination of black phase and eutectic was separated from the main body of the bronze by a fringe of a constituent having a characteristic puce colour. No structure could be developed in it, but it appeared porous. Isolated areas of this material also occurred completely surrounded by α. These are thought to be intrusions from above or below the plane of the section. There were also a few islands of α fringed with puce in the eutectic field. The two eutectics, the red, black, puce, and α constituents occurred in every possible combination. Fig. 6 is a typical example. In this area, which has been etched with ferric chloride, (i) is the eutectoid, (ii) a copper lake, (iii) the puce constituent, and (iv) the nodular eutectic.

The analysis of sound metal from these different impellers showed the material to be a bronze, of tin content 10 to 11 per cent., with 0·3 to 0·4 per cent. phosphorus, and lead, zinc, and iron negligible. The density was 8·02 grammes per cubic centimetre. The scale found on the outside surface of the feed-pump impellers contained Fe_2O_3 50 to 60 per cent., tin 5 to 10 per cent., and copper 0 to 10 per cent., with a little sulphate and phosphate. At a previous date, it had been found that when a bronze was attacked by a solution of bromine in hydrobromic acid, a residue of stannic oxide was left. It seemed probable that stannic oxide would be one of the products of the interdendritic attack, and, on the basis of the above-mentioned observation, a method was devised for estimating the stannic oxide content of attacked bronze.

Drillings taken from a seven-heater extraction pump shroud, which had been attacked throughout its thickness, were examined in comparison with drillings from sound metal on the same impeller, and British Chemical Standard bronze No. 207 was also examined. Reproducible results were obtained, showing 0·1 per cent. SnO_2 in the standard bronze and the unattacked metal; 0·8 to 1·2 per cent. in various whole samples of attacked metal; and up to 2·7 per cent. in fine sievings from the same samples of drillings. It was found that hydrochloric acid containing potassium chlorate behaved in the same way and precisely similar figures for stannic-oxide content were obtained with this reagent. The oxygen content was estimated by

* Paper entitled "A Note on the Selective Corrosion of Phosphor Bronze in Hot-Water Service," presented to the Institute of Metals on Thursday, March 6, 1947. Abridged.

SELECTIVE CORROSION OF PHOSPHOR-BRONZE.

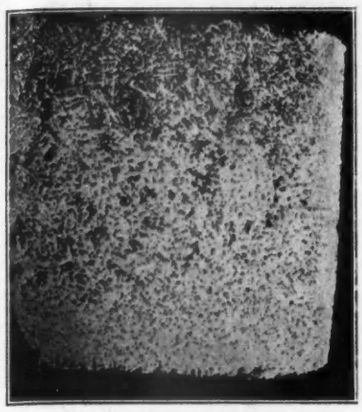


FIG. 1. SECTION OF SHROUD. × 5.

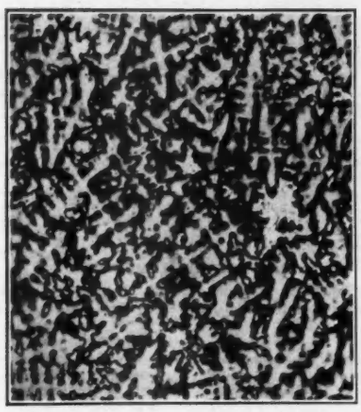


FIG. 2. ATTACKED REGION. × 50.

FIG. 3. COPPER LAKE. × 500.

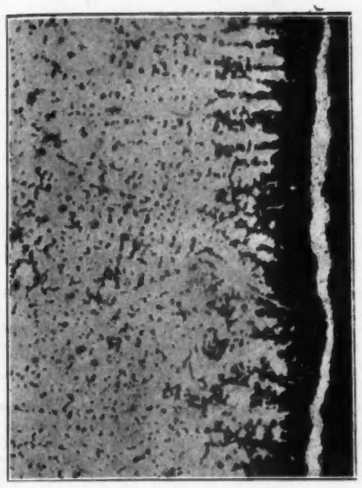


FIG. 4. INSIDE SURFACE OF SHROUD. UNETCHED. × 50.

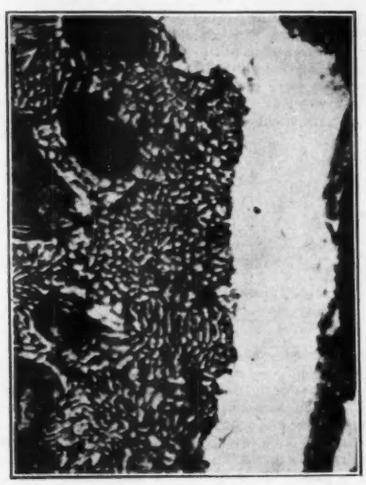


FIG. 5. METALLIC FILM AND EUTECTIC. UNETCHED. × 500.

FIG. 6. COMPLEX AREA. × 500.

reduction of the metal in hydrogen at 300 deg. and 600 deg. C., using two different techniques which gave concordant results. Oxygen contents up to 1·3 and 1·5 per cent. were determined on whole and sieved samples, respectively. Under the conditions of reduction, tin and copper oxides would be reduced to the metal. Stannic oxide contains only a fifth of its weight as oxygen, hence the metal contains about 1 per cent. oxygen combined in some other form than stannic oxide.

Figures for the free energy of formation of copper and tin oxides show that stannic and stannous oxides will probably be produced before cuprous and cupric oxide. Thus, corrosion in a manner similar to dezincification would not be surprising. Bengough and May, in 1924, and Fink, in 1939, among others, have proved that dezincification of brass takes place, at least in part, by complete solution of the brass and redeposition of the copper, occasionally in recognisable crystals. Recently, however, Polushkin and Shuldener* have put forward the view that selective solution is the more important process. It is of interest to consider which process is operative in the present case. The copper lakes appear to be composed of compact metal, and certainly are more solid than the areas immediately surrounding them (Fig. 3). Selective solution of individual atoms of tin from the bronze without transport of copper atoms does not seem capable of explaining this. Selective solution of the tin from the δ-phase would no doubt leave a more porous residue than similar attack on the α-phase, but if this were the cause of difference between the "lakes" and the surrounding area, the porous material, once δ, would be in the centre.

The alternative theory of complete solution and redeposition would require that the bronze be dissolved, and then the copper be deposited on some initial nuclei, which grow to form the "lakes" observed, surrounded by areas containing oxides, hydroxides, etc., chiefly of tin. Since the copper is being laid down by a mechanism similar to electrodeposition, the structure of the "lakes" will be affected by the same factors which influence electrodeposits. The presence of twins in electrodeposits is common and has been associated with the presence of foreign bodies, and it is also known that interruption of current can lead to boundaries and planes of weakness. During the production of the copper "lakes" the pumps will have been shut down and cooled a number of times, and opened for inspection and dried. These variations in conditions will have affected the corrosion reactions and rate of deposition of copper. It is not surprising, therefore, that the "lakes" should show internal structure and twins.

It has been very noticeable that, in every case, attack has been most marked from the external surface of the shroud, and it is desirable to have some explanation of this. The conditions of exposure are similar, except that the relative water velocity on the attacked side is four to five times greater than on the other side. Since, however, in the case of the feed-pump impellers at least, there was some scale adhering to the external surface of the impellers, it seems improbable that the velocity has a great deal of effect, as there cannot have been direct impingement of water on to the metal. After casting, the inside of the impeller is shot-blasted, while the outside surface and the periphery and boss are then machined. This difference in the surface finish is probably the important factor: on the outside the pore system will be in communication with the water, while on the inside the pores will be largely underneath a continuous relatively sound skin, which is possibly further compacted by the shot-blasting.

This theory of invasion by way of the pores agrees with the fact that the backbones of the dendrites are not attacked (Fig. 1), since the porosity is interdendritic. It may, however, be relevant that the backbones will be of low tin content and therefore less liable to attack. Fig. 1 also shows that although the depth of metal made valueless is much greater on the machined side than on the other, the amount of metal dissolved is not vastly different. Such difference as is present is probably a function of the higher velocity and hence smaller amount of scale on the outside surfaces. However, even though appreciable corrosion has taken place at the unmachined side, it is clear that the impeller would be serviceable for many years but for the attack down the pores.

The complex structures on the inside of the shrouds call for explanation. Although the appearance suggests strongly some connection with a eutectoid or eutectic, detailed consideration shows great difficulties in the way of any theory of conversion of the α — δ eutectoid or copper-copper oxide eutectic to the structure found. Both the colour and the results of an X-ray examination show that the metallic striæ and the film are not bronze but probably pure copper. They would appear, therefore, to be electrodeposits. It is probable that the striæ result from local action, solution of bronze at anodes and deposition of copper at cathodes, and the film may also be due to a process wholly local. It is possible, however, that the film is due to action on a larger scale, the internal surface of the shroud acting as a cathode corresponding to anodes elsewhere. The structures seen in Fig. 6 are presumably an intermediate stage in the attack.

Since attack has taken place in alkaline feed-water and also in acid condensate, it would seem that little beyond water is necessary for the attack. From the data obtained by examining a series of pumps it would seem that temperatures over 150 deg. C. are essential. Condensate containing carbon dioxide is more corrosive than feed-water, since the incidence of attack on extraction pumps is much higher than on feed-pump impellers.

* *Metals Technology*, vol. II (7) (1944).

It is concluded, therefore, that the attack is by selective solution analogous to desincification and that solution and redeposition is almost certainly involved. A very great difference has been noted between the damage done to two surfaces of the same piece of metal, that at a machined surface being greater than that at "as cast" surfaces. This has resulted from having exposed the pores in the metal to ingress of liquid, and attack throughout their depth. Had neither surface been machined, or had the metal been free from appreciable porosity, the amount of attack would not have been very important. On the "as cast" surface the attack has progressed in a complex manner, leaving a number of lamellar residues.

NOTES ON NEW BOOKS.

Cutting Tools for Metal Machining. By PROFESSORS MAX KURRHEIN and F. C. LEA. Second edition. Charles Griffin and Company, Limited, 42, Drury-lane, London, W.C.2. [Price 28s. net.]

THE appearance of the second edition of this work follows the presentation of the authors' recent paper, "Nomenclature of the Cutting Edge," to the Institution of Mechanical Engineers, in which a subject treated only briefly in the opening pages of this book was covered in much greater detail. There is undoubtedly room for improvement in the present chaotic nomenclature of the various tool angles; and to this the authors have contributed some valuable missionary efforts. The principal additions in the present work are further sections to the chapter dealing with tool hardening, and a section on finish-cutting tools, forming an appendix. In this, some interesting test results are included, which show that, even under ordinary workshop conditions, a smoother surface can be obtained by using a suitable finish-cutting tool, with a considerable saving in machining time. The specimens were all of mild steel; but it would have been useful if further tests, on other materials, could have been added. The book retains its general nature, and, while giving first principles clearly, does not attempt to include masses of empirical data in tabular form, showing what feeds and speeds are appropriate for various jobs. The standard of production is good; and the illustrations, particularly the line diagrams, are informative. Wisely, the authors include a generous list of references to specialist articles on English, American, and Continental practice, which help to keep up to date a book on a rapidly changing subject.

The Railways of Switzerland. Issued in connection with the Fourteenth International Railway Congress, Lucerne, June, 1947. The Railway Gazette Offices, 33, Tothill-street, Westminster, S.W.1. [Price 5s.]

ALTHOUGH the fact is not indicated in the title or sub-title of this brochure, the International Railway Congress which was held at Lucerne, and therefore the year of publication of the book, both coincide with the centenary of the opening of the first Swiss railway. It is appropriate, therefore, that the anonymous author or authors should attach some importance to the historical aspect of the subject—although the present state of the railways is also well summarised, and illustrated by numerous photographs and maps. The development of the system is described, from the early days of competitive expansion in the west and north, when, from an international point of view, the Swiss railways became southern termini of German and French lines; to the piercing of the Alps with the great tunnels, the Mont Cenis, the Gotthard, the Simplon and the Lötschberg, which transformed the Swiss railways into "the turntable of Europe"; to the nationalisation of the major railways at the end of the Nineteenth Century; and the almost complete electrification after the 1914-18 war. There are chapters devoted to other aspects of the railways, such as rack railways, the track, signalling, steam and internal-combustion traction, electric traction, rolling-stock, and the Rhaetian Railway, which is the largest independent railway in Switzerland. Although Switzerland enjoys the advantage of abundant hydro-electric power, and the railways thereby provide clean and comfortable travel, Diesel locomotives have been built and, as is well known, the first gas-turbine locomotive in the world was built and run in Switzerland. A strong sense of the virility which is characteristic of the Confederation, its industries and railways, is conveyed by this book.

FLIGHT OF BRITISH-ENGINED SOUTH AMERICAN JET FIGHTER.—Messrs. Rolls-Royce Limited, Derby, inform us that on Saturday, August 9, the "Pulque" jet fighter aeroplane, built by the Instituto Aerotecnico, Cordoba, Argentina, made its first flight with successful results. This Argentine jet fighter is powered by a Rolls-Royce "Derwent V" jet-propulsion engine, the production version of which has a thrust of 3,600 lb. and can remain in service for 180 hours between overhauls.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

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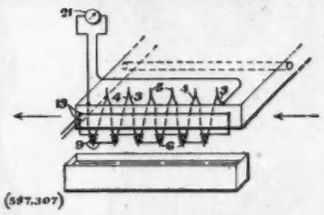
ELECTRICAL APPARATUS.

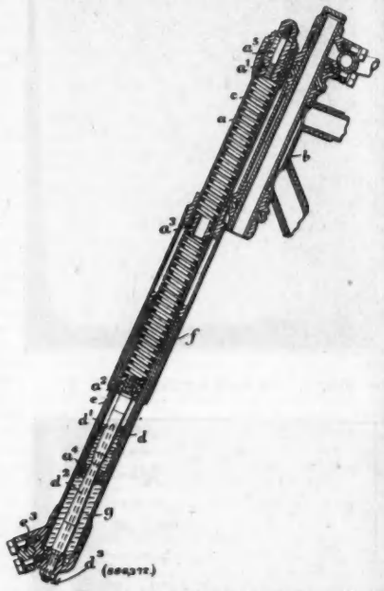
597,307. Hygrometer. H. N. Negretti, of London, P. Negretti, of London, and H. Spencer-Gregory, of London. (3 *Figs.*) October 31, 1945.—The invention is a special type of "wet-and-dry bulb" hygrometer and is used with electrical thermometers. The hygrometer consists of a tubular duct through which a stream of air is forced at controlled speed by a fan. The thermocouples consist of conducting wires 3 and 4, of which the wires 3 are of one metal and the wires 4 of another suitable metal, meeting in junctions 5 and 6, of which the junctions 5 are dry and the junctions 6 are surrounded by heating coils of manganin wire 9 over which is placed a sheath of cotton which is maintained wet. The heating wire 9 is connected at its ends to electrical terminals 13, to which are connected the leads of the heating circuit. The wires from the thermocouples are connected to a galvanometer 21. In operation, first dry air is passed through the tubular duct, the sheath is moistened and the



deflection of the galvanometer 21 is brought to zero by adjusting the current in the heating circuit by an adjustable resistance. The current passing in the heating circuit is then measured by an ammeter. The current passing indicates the rate of heat supplied to the wet junctions 6 and consequently the rate of evaporation from the sheath. Then a stream of air under investigation is passed along the tubular duct at the same temperature and the current required through the heating circuit in order to restore the zero reading of the galvanometer 21 is measured. The relative humidity H is calculated by the formula $H = \frac{C' - C}{C'} \times 100$, where C' is the electric current associated with the dry stream and C that corresponding to the stream of air under investigation. In practice, the use of dry air is only necessary for initially calibrating the hygrometer, the value of C' being found for all possible temperatures that the dry-air stream is likely to have. (*Accepted April 21, 1947.*)

MOTOR VEHICLES.

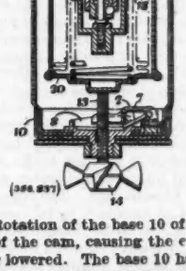
586,372. Motor-Cycle Forks. The Enfield Cycle Company, Limited, of Redditch, Worcester, and H. T. Guide, of Redditch, Worcester. (1 *Fig.*) November 7, 1944.—The invention is a telescopic spring fork, its main feature being the combination of a coiled compression spring with a variable hydraulic damper. A pair of parallel telescopic forks is mounted to form part of a yoke by which the spring fork is mounted on the front pillar *b* of the frame of the cycle. Each telescopic fork consists of a main tube *a*, within which is a coiled compression spring *c*, the spring being harnessed by threading at its upper end to a locating bush a^1 in the upper end of the tube, the lower end of the spring being similarly harnessed to a threaded bush a^2. The bush a^2 forms the piston of a piston rod *d* and is mounted coaxially in the lower part of the main tube *a* forming a guide for the motion of the lower end of the spring *c* to which it is attached. Intermediate threaded guide bushes a^3 in the main tube *a* maintain the alignment of the spring within the tube. The threaded bush a^2 forming the piston is secured to a tapering piston rod *d* which is attached to an outer concentric lower tube *e*. The tube *e* is capable of sliding up and down about the lower part of the main tube *a*. Surrounding a part of the main and lower tubes *a* and *e* is an outer tube *f* which is fixed at its upper end to the outer periphery of the upper main tube *a*. The outer tube *f* provides an annular guide for the flanged upper end of the lower tube *e*. Mounted in the lower end of the main tube *a* is an annulus a^4, with an orifice which surrounds the piston rod *d* at approximately midway in its length. This annulus a^4 determines, by the peripheral contour of the piston rod *d*, the damping effect on the coiled spring *c*, the normal displacement of which is derived from the road wheel attached at e^3. The annulus a^4 is in an oil bath *g*, which is formed in the lower tube *e*, at a predetermined level, by means of a hole d^1 in



the piston rod, which leads into the main bore d^3. The annulus a^4 and the piston rod *d* function as a dash-pot. A plug-controlled vent d^5 at the base of the bore d^3 of the piston rod is provided to predetermine the oil level in the tubes *a* and *e*. The upper end of the main tube contains a cylindrical gauze filter a^5 which allows air to enter or escape from the main tube *a*. The peripheral contour of the piston rod *d* determines the extent of the dash-pot action of the annulus. The central section of the piston rod is tapered, so that a variable flow of the oil takes place. (*Accepted March 17, 1947.*)

MISCELLANEOUS.

586,837. Barometric Bomb Fuse. Imber Research, Limited, of Greenford, Middlesex, and H. C. Hebard, of Greenford, Middlesex. (5 *Figs.*) May 31, 1943.—The fuse explodes the bomb after it has fallen to a predetermined height above sea level and may be adjusted before use to vary the height at which ignition will take place. An aneroid bellows 18 is supported by a screw-threaded spindle 13 in a threaded extension of the fuse casing. The spindle carries a wind-vane 14 on its lower end. When the device is dropped from a height, the wind-vane 14 withdraws the screw-threaded spindle 13 from the casing. Under the action of a spring, the bellows 18 is moved down until it makes contact with a stop lever 2. The lever 2 is pivoted and has a tail 7. The tail 7 runs on the inclined upper edge of a circular



cam disc 8. Rotation of the base 10 of the casing varies the position of the cam, causing the end of the lever 2 to be lifted or lowered. The base 10 has a scale of altitudes engraved on it, calibrated from zero to 10,000 ft. The release of the bomb from the aircraft causes the wind-vane to rotate and withdraw the spindle 13 from contact with the bellows until the spindle and wind-vane fall away. The spring acting on the bellows, forces this down until it makes contact with the stop lever 2 and arms the fuse. As the bomb descends, the pressure increases and the bellows contracts, withdraws the release pin and enables the spring-loaded striker 19, which is retained by two sets of balls and movable sleeves, to operate. (*Accepted April 2, 1947.*)